U.S. Department of Energy

Livermore Site Office, Livermore, California 94550

Lawrence Livermore National Laboratory

Lawrence Livermore National Security, LLC, Livermore, California 94550

UCRL-AR-233862

Final Engineering Evaluation/Cost Analysis for PCB-, Dioxin-, and Furan-contaminated Soil at the Building 850 Firing Table Lawrence Livermore National Laboratory Site 300

Authors:

V. Dibley
L. Ferry
M. Taffet
G. Carli*
E. Friedrich*

Contributors:

S. Chamberlain
B. Daily
S. Dore*
K. Heyward
P. Kim*
G. Lorega
D. Pope*
A. Weston*

February 2008

*Conestoga-Rovers & Associates, Inc.

Environmental Restoration Department

This work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

UCRL-AR-233862

Engineering Evaluation/Cost Analysis for PCB-, Dioxin-, and Furan-contaminated Soil at the Building 850 Firing Table Lawrence Livermore National Laboratory Site 300

Authors:

V. Dibley
L. Ferry
M. Taffet
G. Carli*
E. Friedrich*

Contributors:

S. Chamberlain
B. Daily
S. Dore*
K. Heyward
P. Kim*
G. Lorega
D. Pope*
A. Weston*

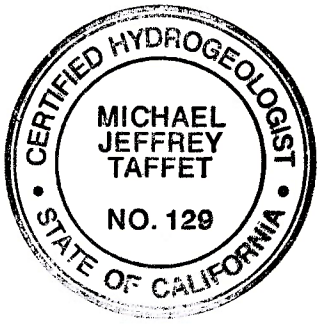
February 2008

*Conestoga-Rovers & Associates, Inc.

Environmental Restoration Department

Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.



Michael J. Taffet February 15, 2007

Michael J. Taffet Ph.D. Date
California Professional Geologist
No. 5616
License expires: May 31, 2009
California Certified Hydrogeologist
No. 129
License expires: May 31, 2009

Table of Contents

List of Figures

List of Tables

Appendices

Executive Summary

This report presents the Engineering Evaluation and Cost Analysis (EE/CA) for remediation of contaminated soils at Building 850 located at the Lawrence Livermore National Laboratory (LLNL) Site 300. This EE/CA has been prepared in accordance with the agreement between United States Department of Energy (DOE), United States Environmental Protection Agency (U.S. EPA), California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) to remediate the polychlorinated biphenyl (PCB)-, dioxin-, and furan-contaminated soil in the Building 850 Firing Table area and the sandpile as a Non-Time Critical Removal Action (hereafter referred to as "removal action") under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Site 300 is a DOE experimental test facility used to conduct research, development, and testing associated with high explosives materials. Site 300 covers 11 square miles, most of which is in San Joaquin County with one-sixth of the western portion of the site located in Alameda County. Site 300 is located in the eastern Altamont Hills about 17 miles east of Livermore and 8.5 miles southwest of downtown Tracy.

Prior to PCBs becoming regulated substances, an estimated 1,000 capacitors were destroyed on the Building 850 Firing Table resulting in PCB contamination of the surrounding soils. Characterization activities at Building 850 commenced in the mid-1980s under the oversight of RWQCB. Site 300 was placed on the National Priorities List in August 1990 and subsequent investigations have been conducted in accordance with CERCLA under the oversight of the three supervising regulatory agencies: U.S. EPA, the RWQCB, and DTSC.

The contaminants of concern in surface soil to be addressed by the Building 850 removal action are PCBs, dioxins, and furans based on a potential risk to onsite workers and impacts to ecological receptors identified in the baseline human health risk assessment and ecological hazard evaluation presented in the Site-Wide Feasibility Study (Ferry et. al., 1999). Neither ground water nor surface water have been impacted by these contaminants, and therefore, these environmental media are not included in this removal action.

No other constituents were detected at concentrations exceeding U.S. EPA Region 9 industrial soil Preliminary Remediation Goals (PRGs). Various metals (beryllium, cadmium, and copper), high melting explosive (HMX), and depleted uranium (primarily uranium-238) were detected in surface soil at Building 850, however, the baseline risk assessment and modeling determined that these constituents did not pose a risk to human or ecological receptors, or a threat to ground water. As a result, the remediation of metals, HMX, and depleted uranium in surface soil is not included in this removal action.

The Building 850 Removal Action Objectives (RAOs) are:

1. Mitigate risk to onsite workers by remediating Building 850 soil and sandpile materials that contain PCB concentrations in excess of U.S. EPA Region 9 industrial soil PRG of 0.74 mg/kg and dioxin and furan compounds in excess of the U.S. EPA Region 9 industrial soil PRG of 1.6×10^{-5} mg/kg for 2,3,7,8-TCDD.

2. Mitigate potential hazard to burrowing owls associated with the PCB-, dioxin-, and furan-contaminated soil. The U.S. EPA Region 9 industrial soil PRG soil cleanup levels for PCBs, dioxins, and furans are sufficiently low to protect ecological receptors.

The U.S. EPA Region 9 industrial soil PRGs for PCBs, and for 2,3,7,8-tetrachloro-dibenzodioxin (TCDD) to represent dioxin and furan compounds, were selected as the cleanup standards for contaminated surface soil at Building 850 in the Interim Site-Wide Record of Decision (DOE, 2001).

Six General Response Actions were identified in this EE/CA that could potentially achieve these RAOs:

1. No further action.
2. Risk and hazard management.
3. *In situ* physical containment (isolation).
4. *In situ* treatment.
5. Excavation and *ex situ* treatment.
6. Excavation and offsite disposal.

The removal action alternatives for the Building 850 soil and sandpile were derived from technologies and response actions combined together based on applicability, effectiveness, implementability, cost, site- and area-specific requirements or considerations, and best professional judgement. Based on an evaluation and screening of General Response Action technologies, the following three removal action alternatives were assembled to meet RAOs and address PCB, dioxin, and furan contamination in the soil and sandpile at Building 850:

Alternative 1: No Further Action.

Alternative 2: Excavation and offsite soil disposal.

Alternative 3: Excavation and onsite soil solidification (*ex situ* treatment).

Alternative 1, "No Further Action," is presented for comparison with other removal action alternatives. Alternative 1 would not provide overall protection of human health and the environment under current or future land-use scenarios because the risks posed by direct contact with the contaminants above the U.S. EPA Region 9 industrial soil PRGs at Building 850 would remain. There is no cost associated with the No Further Action alternative.

Alternative 2 consists of the use of institutional, engineering, and land use controls to prevent exposure of humans and ecological receptors to PCBs, dioxins, and furans in soil as well as the excavation and offsite disposal of PCB-, dioxin-, and furan-contaminated soil. An estimated 15,422 cubic yards (yd^3) of PCB-, dioxin-, and furan-impacted soils would be excavated from an approximated area of 318,000 square feet and transported to appropriate offsite disposal facilities. Once the excavation is complete, verification sampling would be conducted to confirm that the PCB, dioxin, and furan concentrations in soil meet the cleanup standards and the excavated areas would be restored. The total present-worth cost of Alternative 2 is $8,449,922 for excavation, handling, transportation, and disposal of contaminated soil adjacent to the Building 850 Firing Table including verification soil sampling activities.

Alternative 3 also includes institutional, engineering, and land use controls to prevent exposure of humans and ecological receptors to PCB-, dioxin-, and furan-contaminated soil and sandpile. Under Alternative 3, an estimated 15,422 yd^3 of PCB-, dioxin-, and furan-contaminated soil would be excavated, solidified, and consolidated onsite to prevent exposure by onsite workers and ecological receptors. Verification sampling would be conducted once the PCB-, dioxin-, and furan-contaminated soils have been excavated to confirm that the soil meets cleanup standards and the excavated areas would be restored. The solidified and consolidated soil area would be regularly inspected and maintained to protect its integrity. The total present-worth cost of Alternative 3 is $2,042,282 for excavation, relocation, and solidification of PCB-, dioxin-, and furan-contaminated soil at Building 850 including long-term inspection and maintenance.

While both Alternatives 2 and 3 are equally protective of human health and the environment, and meet remedial action objectives and ARARs, Alternative 2 is four times as expensive as Alternative 3 due to the high cost of offsite disposal of the soil. Therefore, based on the evaluation of the alternatives, DOE proposes Alternative 3 as the preferred removal action alternative for remediation of PCB-, dioxin-, and furan-contaminated soil at Building 850.

1. Introduction

In 2001, an interim remedy was selected in the Interim Site-Wide Record of Decision (ROD) (U.S. Department of Energy [DOE], 2001) to mitigate the risk to workers associated with polychlorinated biphenyls (PCBs), dioxins, and furans in soil and the threat to ground water presented by a tritium-contaminated sandpile at the Building 850 Firing Table. The interim remedy consisted of the excavation and offsite disposal of the contaminated soil and sandpile. In 2001, the estimated cost to excavate and dispose of the contaminated soil and sandpile was approximately $1.4 million (M). By the time the Interim Remedial Design Report for Building 850 (Taffet et al., 2004) was prepared, the estimated volume of contaminated soil increased as well as the cost of excavation, transportation, and disposal, increasing the total cost estimate to $4.8 M. DOE scheduled the activity to be completed in fiscal year (FY) 2006. As the planning for the FY 2006 activity proceeded, the cost estimates for the excavation, transportation, and disposal of contaminated soil increased to over $8M. As a result, the interim remedy identified for the contaminated soil at the Building 850 Firing Table in 2001 was no longer considered economically practicable. In addition, other more cost-effective technologies were identified that were capable of addressing the PCBs, dioxins, and furans in an equally protective manner.

In 2006, DOE, the U.S. Environmental Protection Agency (U.S. EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB) agreed to conduct remediation of PCB-, dioxin-, and furan-contaminated soil at the Building 850 Firing Table as a Non-Time Critical Removal Action (hereafter referred to as "removal action") under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). In 2006, additional sampling and analysis of the sandpile adjacent to Building 850 Firing Table showed that the current maximum tritium activities were not a threat to ground water. However, PCBs were detected in the sandpile at concentrations of up to 50.4 milligrams per kilogram (mg/kg). Based on these data, DOE and Lawrence Livermore National Laboratory (LLNL) requested that the sandpile be included in this removal action. The three regulatory agencies agreed.

The purpose of a CERCLA removal action is to provide for timely remediation of the environmental contamination thereby preventing risks or impacts to human health and the environment. The specific goals for this removal action are to mitigate risk to human health and the potential hazard to ecological receptors associated with the PCB-, dioxin-, and furan-contaminated soil and sandpile at the Building 850 Firing Table.

As part of the removal action process, DOE and LLNL prepared this Engineering Evaluation/Cost Analysis (EE/CA) to evaluate several potential removal action alternatives that could be implemented to address contaminated soil at Building 850. Following evaluation of these alternatives, DOE, U.S. EPA, DTSC, and the RWQCB will identify a preferred removal action alternative. After consideration of public input, a removal action will be selected in an Action Memorandum and subsequently implemented.

This EE/CA presents the following information for the Building 850 removal action:

- A brief site description and background information (Section 2);

- A site characterization and risk assessment summary (Section 3);
- Identification of removal action objectives (Section 4);
- Identification and screening of general response actions and technologies (Section 5);
- A description of the alternatives (Section 6);
- A detailed evaluation of the alternatives (Section 7);
- A comparative analysis of alternatives (Section 8); and
- A recommended alternative (Section 9).

2. Site Description and Background

LLNL Site 300 is a DOE experimental test facility operated by the Lawrence Livermore National Security, Limited Liability Corporation. The facility is located in the eastern Altamont Hills about 17 miles east of Livermore and 8.5 miles southwest of downtown Tracy (Figure 2-1). LLNL Site 300 covers 11 square miles (mi^2), most of which is in San Joaquin County. The western one-sixth of the property is located in Alameda County. Site 300 is used to conduct research, development, and testing associated with high explosives (HE) materials.

Building 850 is located in operable unit (OU) 5 in the northwest part of Site 300 (Figure 2-2). The facility was constructed in 1960 and has since been used to conduct hydrodynamic experiments. These experiments were conducted on the firing table. The Building 850 bunker is located directly adjacent to the firing table and the rear of the building abuts the elevated firing table. The front of Building 850 is at normal ground surface. Figure 2-3 shows the locations of buildings, the firing table, and monitoring wells in the vicinity of Building 850. An average of two personnel may be present daily at Building 850. Maintenance and ground water monitoring personnel also periodically perform work in the Building 850 area.

Building 850 and the adjacent firing table are located in a topographic bowl with elevations ranging from about 1,310 feet (ft) above mean sea level (MSL) at the firing table to over 1,500 ft above MSL on the surrounding hillside. The firing table is covered with up to 5 ft of pea gravel used to absorb shot blasts and minimize impact to bunker occupants. Much of the surrounding hillside is covered with a 0 to 5 ft thickness of soil, and native perennial and introduced annual grasses and associated forbs, including the Big Tar plant, a California Native Plant Society list 1B species. However, in places there are steep rock outcrops that are generally devoid of both soil and vegetation. The climate is semiarid and windy with an average annual rainfall of 10.2 inches.

An extensive California ground squirrel colony is present in the Building 850 area. Burrowing owls have also historically used this area for nesting. The Building 850 area is located within 1 kilometer (km) of a known California tiger salamander breeding pool. The proximity to the breeding pool and the presence of the ground squirrel colony makes this area suitable upland habitat for the California tiger salamander. Raptors, including Golden Eagles, have been observed foraging at the Site.

Prior to PCBs becoming regulated substances, an estimated 1,000 capacitors were destroyed on the firing table resulting in the contamination of soil on the slopes and flat areas around the immediate firing table area with PCBs, dioxins, and furans. In 1990, visible fragments of

metallic debris that potentially contained PCBs were removed from the slopes above the firing table area.

From 1962 to 1972, sand was stockpiled near Building 850 and was periodically used during large experiments. This sand was reused and as a result, gradually became contaminated with tritium and PCBs. The sandpile consists of approximately 460 cubic yards (yd^3) of sand (Figure 2-3). In 1990, the material was covered with plastic sheeting to minimize the infiltration of rainwater.

Other contamination that resulted from activities at Building 850 is described in the Site-Wide Remediation Investigation (SWRI) report (Webster-Scholten et al., 1994), and the Site-Wide Feasibility Study (Ferry et al., 1999). Interim remedies were selected for contaminants of concern (COCs) in subsurface soil, ground water, and surface water at Building 850 in the Interim Site-Wide ROD (DOE, 2001). The cleanup progress for these other COCs is documented in the Site-Wide Remediation Evaluation Summary Report (Ferry et al., 2006) and a preferred final remedy is presented in the Site-Wide Proposed Plan (DOE, 2007). For this reason, COCs other than PCBs, dioxins, and furans in the Building 850 soil and sandpile are not discussed further in this EE/CA except to the extent they may affect the remediation of the contaminated soil.

3. Site Characterization

Site characterization at Building 850 began in the mid-1980s. Prior to August 1990, investigations of potential contamination at Building 850 were conducted under the oversight of the RWQCB. Site 300 was placed on the National Priorities List (NPL) in August 1990. Since then, all investigations have been conducted in accordance with CERCLA under the oversight of the three supervising regulatory agencies: U.S. EPA, the RWQCB, and DTSC. DOE is the lead agency for all environmental restoration activities at Site 300.

Early site characterization work is summarized in the SWRI report. Subsequent characterization work was summarized in an Addendum to the SWRI (Taffet et al., 1996) and the Interim Remedial Design for Building 850.

This section summarizes the nature and extent of PCB-, dioxin-, and furan-contaminated soil and sandpile at Building 850 (Section 3.1), analytical data (Section 3.2), and the results of previous human health risk and ecological hazard evaluations related to these contaminants (Section 3.3).

3.1. Nature and Extent of PCB, Dioxin, and Furan Contamination at Building 850

The COCs addressed by the EE/CA removal action are PCBs, dioxins, and furans in soil and the sandpile at Building 850. As a result of the dispersal of contaminated shrapnel during explosives testing, surface soil (defined as the upper 6 inches of soil), and shallow subsurface soil (defined as soil greater than 6 inches but less than 3 ft below ground surface [bgs]) at the Building 850 Firing Table area were contaminated with PCBs, and dioxin and furan compounds. PCBs were also detected in the sandpile located near Building 850.

PCBs, dioxins, and furans have not been detected in Building 850 ground water or surface water. Therefore, a discussion of contaminants in these environmental media is not included in this EE/CA. Additional information on COCs in ground water and surface water is presented in the Interim Remedial Design for Building 850, SWRI, SWRI addendum, and the Compliance Monitoring Reports (Dibley et al., 2004a, 200b, 2005a, 2005b, 2006a, 2006b, and 2007).

Various metals (beryllium, cadmium, and copper), High Melting Explosive (HMX), and depleted uranium (primarily uranium-238 [^{238}U]) were also detected in shallow soil at Building 850. However, the Site-Wide Feasibility Study risk assessment and modeling determined that these constituents did not pose a risk to human or ecological receptors, or a threat to ground water. In addition, concentrations of these constituents are all below U.S. EPA Region 9 industrial soil Preliminary Remediation Goals (PRGs). Therefore, the remediation of metals, HMX, and depleted uranium in soil is not an objective of this proposed removal action. However, the implemented design of the removal action will also isolate these constituents from potential human and ecological receptors.

This section discusses the nature and extent of PCBs in Building 850 soil and the sandpile (Section 3.1.1); dioxin and furan contamination in soil (Section 3.1.2); and metals, HMX, and depleted uranium in soil (Section 3.1.3).

3.1.1. PCBs in Building 850 Soil and the Sandpile

Samples of surface and subsurface soil and sandpile material were analyzed for PCB compounds to define their nature and extent. The results are summarized below. Samples of soil were not collected for PCB analysis from beneath asphalt surface covers, concrete, and roads (hatched areas on Figures 3-1 and 3-2). The asphalt covers and roads are routinely repaved and PCBs have low mobility, thus there is minimal potential for contamination of the soil underlying the pavement. The soil beneath the pavement is not a current exposure pathway. However, because soil sampling has not occurred beneath the asphalt, institutional controls will ensure that any future excavation beneath the asphalt or asphalt removal is accompanied by sampling and PCB analysis to verify that PCBs are not present in soil beneath the asphalt and to avoid future exposure.

As part of the Site-Wide Feasibility Study risk assessment, the fate and transport of PCBs in soil was modeled to ground water. This modeling indicated that PCBs would not reach underlying ground water. In addition, PCBs have not been detected in ground water.

Surface soil sample results

A total of 80 surface soil samples were collected at depths of up to 0.5 ft bgs in 1994, 1995, and 2003 from the Building 850 Firing Table area and surrounding hillslopes. These samples were analyzed for PCB compounds (Aroclors) by EPA Methods 8080 or 8082C, or for total PCBs with field test kits utilizing immunoassay methods. The immunoassay sample results provided semi-quantitative information on the locations where total PCBs exceeded the 0.5 mg/kg detection limit.

PCB concentrations detected in these 80 samples ranged from less than the reporting limit of 0.004 mg/kg to a maximum concentration of 180 mg/kg collected from sample location 3SS-850-142. Forty-six of these samples contained PCBs at concentrations above the U.S. EPA

Region 9 industrial soil PRG of 0.74 mg/kg. Sample data are shown on Figure 3-1 and are presented in Appendix A, Table A-1.

In October 2005, seven surface soil samples were collected from the hillslopes to develop a profile for potential offsite disposal of the soil. Because the samples were collected in areas where the highest PCB concentrations had already been defined, PCB concentrations in all these samples exceeded the industrial PRG. The maximum PCB concentration in these samples was 65 mg/kg (3SS-850-212). Sample data are also presented in Appendix A, Table A-1.

The lateral extent of PCBs in surface soil exceeding the 0.74 mg/kg industrial PRG is confined to a 100 to 500 ft radius around the firing table and includes an estimated area of approximately 318,000 square feet (ft^2) (Figure 3-1). In addition to the 0.74 mg/kg PCB PRG contour, the 50 mg/kg contours are shown on Figure 3-1, because the cost of potential removal action alternatives may be affected by concentrations of PCBs in excess of 50 mg/kg because the offsite disposal of such soils is regulated under the Federal Toxic Substances Control Act (TSCA). PCB concentrations in excess of 50 mg/kg are limited to four sample locations (3SS-850-142, -206, -212, and -216).

Subsurface soil sample results

In 1994 and 2003, 16 soil samples were collected at depths between 0.5 ft and 4 ft bgs for PCB analysis by U.S. EPA Methods 8080 or 8082C. These data are shown on Figure 3-2 and in Appendix A, Table A-2. PCB concentrations detected in these samples ranged from less than the reporting limit of 0.02 mg/kg to a maximum concentration of 120 mg/kg collected from a 0.5 ft depth at sample location 3SS-850-142. Twelve of the 16 samples contained total PCB concentrations above the 0.74 mg/kg industrial PRG and two contained more than 50 mg/kg of total PCBs. PCBs were identified at a maximum depth of 2.7 ft bgs at sample location 3SS-850-142 (14.5 mg/kg).

Sandpile sample results

From 1962 to 1972, a large volume of sand was stockpiled and used near the Building 850 Firing Table. In 2006, soil samples were collected from the Building 850 sandpile to develop a profile for potential offsite disposal of the soil. A total of five soil samples were collected from the sandpile. Samples collected from the full interval of 2.5 to 7.5 ft or 5.0 to 7.5 ft depth were mixed to create composite samples. No samples were collected beneath the sandpile. A maximum PCB concentration of 50.4 mg/kg was detected in the sample from borehole B-850-2220 (5.0 to 7.5 ft depth) (Figure 3-1). Sample data are shown in Figure 3-2 and are presented in Appendix A, Table A-2, where sandpile samples (B-850-2219 through B-850-2223) are flagged with "DB" because the samples were diluted (D) prior to analysis and 0.0016 mg/kg PCB 1254 was detected in the method blank (B). The concentration of PCB 1254 detected in the method blank is three orders of magnitude lower than the sample concentrations. Thus, the sample results are considered usable.

Residual soil tritium activities in the sandpile were compared with Soil Screening Levels (SSLs) for the soil to ground water pathway using EPA soil screening guidance. The maximum detected tritium activity of 19.2 picoCuries per gram (pCi/g) is an order-of-magnitude lower than the SSL for a dilution attenuation factor (DAF) of 20 (165 pCi/g). Based on this analysis, the tritium in the sandpile is not a threat to ground water.

3.1.2. Dioxins and Furans in Building 850 Soil

Ten soil samples were collected and analyzed for 11 dioxin compounds and 14 furan compounds by EPA Method 8290. These data are presented in Appendix A, Table A-3. Where detected, total tetrachloro-di-benzodioxin (TCDD) concentrations ranged from 0.7 picograms per gram (pg/g) (parts per trillion) to 4.3 pg/g. Tetrachloro-di-benzofuran (TCDF) (total) concentrations in surface soil ranged from 29 pg/g to 15,000 pg/g. As reported in the SWRI Addendum, a total toxicity equivalent concentration (TEC) of the dioxin/furan compounds was calculated for each sample. This concentration was calculated by multiplying the measured dioxin/furan compound concentration by the World Health Organization Toxicity Equivalence Factors (Van den Burg, 1998). This approach related the toxicity of the other 209 chloro-di-benzo-p-dioxins (CDD) and chloro-di-benzofurans (CDF) compounds to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD). Because 2,3,7,8-TCDD is one of the most potent toxic dioxins, it is used as a reference for all other dioxins and furans. The CDD 1,2,3,7,8-pentachlorodibenzo-p-dioxin is of a similar potency, while the other members of the subset are 10 to 10,000 times less toxic. Six samples contained total TCDD equivalent concentrations above EPA's industrial soil PRG of 1.6×10^{-5} mg/kg. The maximum calculated total TCDD equivalent concentration was 6.19×10^{-3} mg/kg. The highest concentrations were found near the firing table. Figure 3-3 shows the distribution of these compounds and TCDD equivalents in surface soil at Building 850. The lateral extent of the industrial soil PRG for total TCDD equivalents is shown on Figure 3-3. The total equivalent concentrations calculations for the ten samples collected for dioxin and furan analyses are presented in Appendix B.

Modeling of potential dioxin migration indicated no threat to ground water (Ferry et al., 1999). Although potential impact of furans to ground water was calculated by modeling, worst-case concentrations were below the Maximum Contaminant Level (MCL). In addition, dioxins and furans have not been detected in ground water.

3.1.3. Other Constituents in Building 850 Soil and the Sandpile

Other contaminants in soil at Building 850 include ^{238}U from depleted uranium, tritium, beryllium, cadmium, copper, and HMX. However, these contaminants are not part of the removal action because they do not pose an unacceptable risk to human or ecological receptors or a significant threat to ground water.

Between 1989 and 1994, sixty-two soil samples were collected from the Building 850 Firing Table area and surrounding hillslopes and analyzed for uranium isotopes. Uranium isotope and uranium-235/uranium-238 ($^{235}U/^{238}U$) atom ratio soil data are presented in Appendix A, Tables A-4 and A-5. The maximum ^{238}U activity detected in these samples was 24.8 pCi/g; below the U.S. EPA outdoor worker soil PRG of 36.8 pCi/g. All soil samples except one (3SS-850-128) had $^{238}U/^{235}U$ mass ratios below 0.0072 +/- 0.00005, indicating some addition of depleted uranium to the natural background uranium. Four of the 62 samples contained ^{238}U in excess of the 3.1 pCi/g background. These samples were both collected from within 200 ft of the Building 850 Firing Table.

Between 1988 and 1990, 161 soil samples were collected from five boreholes drilled through the Building 850 Firing Table and analyzed for tritium. Tritium soil data are presented in Appendix A, Table A-6. Tritium was detected at a maximum activity of 1.1×10^{3} pCi/g at a

depth of 5.5 ft below the firing table surface. No surface soil samples (i.e., <0.5 ft bgs) were collected for tritium analysis because, due to evaporation, there is insufficient soil moisture for tritium to be present in measurable quantities.

In April 2006, five subsurface soil samples were collected from the sandpile for tritium analysis. Samples collected from the full interval of 2.5 to 7.5 ft or 5.0 to 7.5 ft depth were mixed to create composite samples. Soil tritium activities in the sandpile samples were compared with Soil Screening Levels (SSLs) for the soil to ground water pathway using EPA soil screening guidance. The maximum detected tritium activity of 19.2 picoCuries per gram (pCi/g) is an order-of-magnitude lower than the SSL for a dilution attenuation factor (DAF) of 20 (165 pCi/g). Based on this analysis, the tritium in the sandpile is not a threat to ground water.

Thirty-five soil samples collected and analyzed for metals indicated maximum total beryllium, cadmium, and copper concentrations in soil of 15, 8.6, and 1,000 mg/kg, respectively. Total Threshold Leaching Concentration (TTLC) metal data for these soil samples are presented in Appendix A, Table A-7. The maximum concentrations of these metals detected in soil were well below EPA Region 9's industrial soil PRGs of 1.9×10^3, 4.5×10^2, and 4.1×10^4 mg/kg, respectively. There is no unacceptable risk or impact to ground water associated with metals in soil.

Thirty-two soil samples were collected and analyzed for HE compounds (HMX, Research Department Explosive [RDX], and trinitrotoluene [TNT]) by EPA Method 8330. Data for these soil sample analyses are presented in Appendix A, Table A-8. HMX was detected in one sample (3SS-850-107) collected approximately 20 ft west of the firing table at a concentration of 2.4 mg/kg, below EPA's industrial soil PRG of 16 mg/kg. RDX and TNT were not detected in any of these samples. Based on this limited extent of explosives compounds, these chemicals are not considered a risk or threat to ground water or other environmental media.

3.2. Analytical Data

The surface soil and subsurface soil/rock data relevant to the removal action alternatives discussed in this EE/CA are presented in Appendix A. Soil sample data for PCBs, dioxins, and furans, the drivers for this removal action, are presented in Tables A-1 through A-3. While uranium, tritium, beryllium, cadmium, copper, and HMX are not specifically targeted as part of the removal action because they do not pose an unacceptable risk to human or ecological receptors or a significant threat to ground water, soil sample data for these constituents are presented in Appendix A (Tables A-4 through A-8) for completeness.

Analytical data for ground water and surface water samples collected in the Building 850 OU are not included in this EE/CA as they are not relevant to this removal action. These data are summarized in the Building 850 Remedial Design report. The annual and semi-annual Compliance Monitoring Reports summarize additional ground water data collected in the Building 850 OU.

3.3. Risk Assessment Summary

The baseline risk assessment (Ferry et al., 1999) estimated an excess cancer risk of 5×10^{-4} to onsite workers resulting from the potential inhalation or ingestion of re-suspended particulates

and direct dermal exposure to surface soil contaminated with PCBs at the Building 850 Firing Table. In addition, a risk of 1×10^{-4} was calculated for potential inhalation/ingestion of re-suspended particulates and direct dermal exposure to surface soil contaminated with dioxins and furans. An ecological risk assessment of PCBs, dioxins, and furans at Building 850 was conducted in 2004 (Dibley et al., 2005b). The results of this evaluation showed burrowing owls were at risk from exposure to PCBs in surface soil at Building 850. PCBs, dioxins, and furans have not been detected in ground water and modeling indicates that PCBs in soil will not impact ground water in the future. Therefore, there is no risk of exposure to PCBs, dioxins, and furans in ground water.

No unacceptable risk or threat to ground water was identified for depleted uranium or HMX in soil at the Building 850 Firing Table. There is no unacceptable risk or impact to ground water associated with metals in soil.

4. Identification of Removal Action Objectives

The Removal Action Objectives (RAOs) for this removal action are to:

1. Mitigate risk to onsite workers by remediating the Building 850 soil and sandpile that contains PCB concentrations in excess of EPA Region 9 industrial soil PRG of 0.74 mg/kg and dioxin and furan compounds in excess of the industrial soil PRG of 1.6×10^{-5} mg/kg for 2,3,7,8-TCDD.
2. Mitigate potential hazard to burrowing owls associated with the PCB-, dioxin-, and furan-contaminated surface soil. The EPA Region 9 industrial soil PRG soil cleanup levels for PCBs, dioxins, and furans are sufficiently low to protect ecological receptors.

This removal action will be considered the final, long-term remedy for the PCB-, dioxin-, and furan-contaminated soil at Building 850.

4.1. Statutory Limits on Removal Actions

Because this removal action is not Superfund-financed, the $2 million and 12-month statutory limits on removal actions do not apply.

4.2. Determination of Removal Scope

The scope of the removal action is to clean up PCBs, dioxins, and furans in the Building 850 soil and sandpile to meet EPA's industrial soil PRGs. The cleanup standards for the Building 850 soils selected in the Interim Site-Wide ROD are EPA's industrial soil PRG of 0.74 mg/kg for PCBs, and EPA's industrial soil PRG of 1.6×10^{-5} mg/kg for 2,3,7,8-TCDD for dioxin and furan compounds. These cleanup criteria are conservative and protective.

4.3. Determination of Removal Schedule

The removal action is expected to be initiated by September 30, 2008. The schedule for the removal action is presented in Table 4-1.

5. Identification and Screening of General Response Actions and Removal Action Technologies

Section 5.1 describes General Response Actions available to address the RAOs outlined in Section 4. Section 5.2 screens remedial technologies that may be included in the General Response Action based on applicability, effectiveness, implementability, and cost. Various actions and technologies that passed the screening were combined to form the removal action alternatives presented in Chapter 6.

5.1. General Response Actions

General Response Actions describe those actions that can potentially achieve the removal action objectives established in Section 4. These actions are intended to mitigate potential exposure of onsite workers and ecological receptors to PCBs, dioxins, and furans in the Building 850 soil and sandpile. Six General Response Actions have been identified:

1. No further action.
2. Risk and hazard management.
3. *In situ* physical containment (isolation).
4. *In situ* treatment.
5. Excavation and *ex situ* treatment.
6. Excavation and offsite disposal.

5.1.1. No Further Action

Under CERCLA, a no-action response action provides a basis for comparison with other remedial or removal action alternatives. All ongoing activities would cease and no measures would be taken to remove, contain, or prevent exposure to the PCB-, dioxin-, and furan-contaminated soil.

5.1.2. Risk and Hazard Management

Risk and hazard management may include institutional, land use, and/or engineering controls that can be used as a General Response Action to mitigate exposure to contaminated media where the risk exceeds 10^{-6} or the hazard index for human or ecological receptors exceeds 1. Risk and hazard management are commonly employed in conjunction with other active removal action components.

Institutional and land use controls are non-engineered actions or measures used to prevent or limit the potential for human exposure to contaminants and to protect the integrity of the removal action. These controls can involve a range of measures, from posting signs and installing fences, to specified restrictions on the use of property. Also included are operational safety procedures that are used during implementation of the removal action to ensure worker safety.

Engineering controls prevent exposure to contaminants through the use of machinery, equipment, or other physical methods to eliminate the exposure pathway such as soil wetting during remediation to prevent suspension and worker inhalation of contaminated soil particles.

5.1.3. *In Situ* Physical Containment

In situ physical containment involves the use of constructed barriers, such as a low permeability cover, placed over the contaminated soil on the hillslopes and area surrounding the firing table to contain and prevent direct contact with or inhalation of contaminants in the soil. In addition, the cover provides long-term protection against erosion and subsequent surficial and aerial transport of contaminants. In general, the physical containment technology provides good isolation of the contaminated soil but would require long-term maintenance.

Materials which may be used in the construction of low permeability covers may include:

1) Concrete.
2) Asphalt.
3) Clay.
4) Synthetic materials.

5.1.4. *In Situ* Treatment

In situ treatment methods destroy or convert contaminants in soil to less toxic compounds to eliminate exposure risk. Treatment would occur *in situ* where contaminated soil is present in the vicinity of and on the hillslopes surrounding the Building 850 Firing Table. Possible *in situ* treatment methods include thermal desorption, ozone injection, and vitrification.

5.1.5. Excavation and *Ex Situ* Treatment

Excavation and *ex situ* treatment methods involve removal of contaminated soil from the firing table area and surrounding hillslopes that contains PCBs, dioxins, and furans at concentrations above the soil cleanup standards, with treatment at an onsite location. Possible *ex situ* treatment methods include solvent extraction, solvated electron technology, biodegradation, and soil solidification.

5.1.6. Excavation and Offsite Disposal

Excavation includes removal of contaminated soil from the Building 850 area and surrounding hillslopes that contains PCBs, dioxins, and furans at concentrations above the soil cleanup standards. The excavated soil would be disposed offsite at appropriately permitted disposal facilities.

5.2. Evaluation and Screening of Remedial Technologies

This section discusses the evaluation and screening of various technologies that were considered potentially capable of remediating PCBs, dioxins, and furans in the Building 850 soil and sandpile to mitigate risk to onsite workers and potential impacts to ecological receptors.

These technologies were evaluated against four criteria: applicability, effectiveness, implementability, and cost.

As part of this screening, DOE/LLNL evaluated seventeen technologies for potential application for the Building 850 soil removal action. In the first step of the screening process, technologies were evaluated for their applicability and effectiveness for remediation of PCBs, dioxins, and furans in soil. The applicable and effective technologies were then assessed for the implementability of the technology given site-specific conditions. Comparative costs (high, medium, and low) to implement these technologies were estimated.

Table 5-1 lists the General Response Actions, technologies, and the results of this screening process. One or more potentially viable technologies were evaluated for each type of General Response Action. The table documents the key reasons for retaining or eliminating a technology from further consideration. The last column of Table 5-1 indicates whether the technology was retained for the development of the removal action alternatives.

Several technologies were screened out because while these technologies were potentially effective in concept, they were not proven for the remediation of PCBs. Other technologies were screened out due to: (1) site-specific logistical considerations that made it very difficult to implement, (2) the long time period required to treat the contaminated soil, (3) the creation of secondary hazardous waste stream, and/or (4) the high cost to implement. While the costs to implement soil excavation and offsite disposal were very high, this remediation technology was retained and incorporated into an alternative for comparison purposes because it was the interim remedy selected for contaminated soil at Building 850 in the Site-Wide Interim ROD.

Retained technologies include:

- Institutional controls.
- Ecological hazard controls.
- Excavation.
- Offsite disposal.
- Soil solidification and onsite disposal.

Technologies that were screened out include:

- In situ covers.
- Thermal desorption.
- Ozone treatment.
- Vitrification.
- Solvent extraction.
- Solvated electron treatment.
- Biodegradation.
- Chemical dehalogenation: Base-catalyzed decomposition process (BCDP).
- MechanoChemical Destruction (MCD).

Although an *in situ* cover could be effective in preventing exposure to the PCB-bearing soil, this technology may not be implementable due to the hillslope topography. Long-term maintenance of the remediated areas might also prove difficult. Thermal desorption and solvent extraction, while technically feasible, proven technologies for the treatment of PCBs in soil, were screened out due to: (1) the high cost to implement, (2) the long time period required to treat the contaminated soil, and (3) the generation of a secondary waste stream. In addition, thermal desorption poses a multitude of safety concerns. Ozone treatment and biodegradation are newer technologies that have still not been proven for use in transforming PCBs to innocuous products over a range of environmental settings. Vitrification was deemed not technically or economically feasible due to cost, efficiency, and/or safety factors, and therefore was screened out from further evaluation. Solvated electron treatment, although proven effective, creates a secondary liquid waste, poses safety issues, and is very expensive. Chemical de-halogenation and MechanoChemical Destruction are also new technologies that have not been proven to transform PCBs to innocuous by-products efficiently and over a range of applications. These two technologies are also very expensive.

Soil solidification is a proven, widely used technology for the treatment of PCB-contaminated soils and represented the best balance of effectiveness, implementability, and cost. It was therefore was retained and incorporated into a removal action alternative. The U.S. EPA has identified soil solidification treatment as Best Demonstrated Available Technology for at least 57 hazardous wastes and has selected this technology for 25% of its Superfund site remediation projects. While the cost to implement offsite disposal of excavated soil was very high, this remediation technology was retained and incorporated into an alternative for comparison purposes because it was the selected interim remedy for contaminated soil at Building 850 in the Interim Site-Wide ROD.

6. Removal Action Alternatives for Building 850 Soil

In this section, removal action alternatives are described that address PCBs, dioxins, and furans in the Building 850 soil and sandpile. Each of the removal action alternatives were developed from retained technologies and response actions described in Section 5.

To develop these removal action alternatives, retained technologies and response actions were combined based on applicability, effectiveness, implementability, cost, site- and area-specific requirements or considerations, and best professional judgment.

Three removal action alternatives were assembled to meet RAOs and address PCBs, dioxins, and furans in soil at Building 850:

1. No further action (Section 6.1).
2. Excavation and offsite soil disposal (Section 6.2).
3. Excavation and onsite solidification, and consolidation (Section 6.3).

6.1. Alternative 1 - No Further Action

A No Further Action alternative is generally required by EPA guidance to provide a basis for comparison with other remedial actions and is the postulated basis of the baseline risk assessment. All ongoing activities would cease and no measures would be taken to remove, contain, or prevent exposure to the PCB-, dioxin-, and furan-contaminated soil. The No Further Action alternative will not meet RAOs. However, the no further action alternative is retained as a baseline for comparison with other general response actions and technologies.

There is no cost associated with the no further action alternative.

6.2. Alternative 2 - Excavation and Offsite Soil Disposal

The primary components of Alternative 2 include:

1. Institutional, engineering, and land use controls to prevent exposure of humans and ecological receptors to PCBs, dioxins, and furans in surface soil.

2. Excavation and offsite disposal of contaminated soil and sandpile.

These components are described in Sections 6.2.1 and 6.2.2 below.

The present-worth cost of Alternative 2 is $8,449,922 for excavation, handling, transportation, and offsite disposal of the contaminated soil and sandpile adjacent to the Building 850 Firing Table and for verification sampling. Detailed cost estimates for this alternative are presented in Appendix C, Table C-1.

6.2.1. Engineering, Institutional, and Land Use Controls

As part of Alternative 2, engineering, institutional and land use controls will be implemented as necessary to:

1. Ensure RAOs are achieved.

2. Manage risk and/or hazard by preventing exposure of humans and ecological receptors to PCBs, dioxins, and furans.

The following engineering, institutional, and land use controls will be maintained to prevent exposure to the contaminated soil at the Building 850 firing table:

- Prevent inadvertent exposure to contaminated soil at Building 850 by non-authorized personnel by controlling access to Site 300.

- Maintain land use restrictions and control activities in the vicinity of the Building 850 Firing Table until remediation of the PCB-, dioxin-, and furan-contaminated soil and sandpile reduces the risk to onsite workers to less than 10^{-6}.

- Control activities to prevent onsite worker exposure to contaminants in soil during removal action excavation, handling, and transport. Controls may consist of a combination of engineered controls (e.g., wetting soil during excavation and covering

excavated soil prior to offsite transport), personal protective equipment, and preventing site access to personnel not involved in removal action, as necessary.

- Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that subsurface soil does not pose an exposure risk to onsite workers. Inspect stockpiled soil for the presence of animals prior to offsite disposal.
- Prohibit the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use, until and unless a risk assessment is performed that shows no unacceptable risk for residential or unrestricted land use.

These controls are described in further detail in Table 6-1.

6.2.2. Excavation and Offsite Disposal of Contaminated Soil and Sandpile

As part of Alternative 2, PCB-, dioxin-, and furan-contaminated soil in the vicinity of the Building 850 Firing Table and the sandpile would be removed to meet soil cleanup standards. This material would be transported to offsite permitted facilities for disposal.

Soil samples were collected from the firing table area to define the area and volume of soil that would require excavation and disposal. Based on the results of chemical analyses, a 0.74 mg/kg isoconcentration contour for PCBs was constructed by using all the surface soil PCB data to plot the 0.74 mg/kg industrial PRG (cleanup standard) total PCB contour (Figure 3-1). This contour defines the overall extent of soil excavation area to a depth of 1 ft (Figure 6-1). The areal extent of soil contamination is estimated to be approximately 318,000 ft^2. Based on the assumption that the top 1 ft of soil would be removed from within the 0.74 mg/kg contour area, a volume of 11,778 yd^3 (i.e., 17,667 tons) of soil would require excavation. However, because the soil cover is less than 1 ft thick in some areas, some reduction in excavation volume may result.In addition, PCBs were detected at some soil sampling locations at concentrations above the 0.74 mg/kg PRG at depths greater than 1 ft. The limits of the 2 and 3 ft depth of excavation contours (shown on Figure 6-1) were developed by contouring the subsurface soil sample data to define the limits of the 0.74 mg/kg PRG with depth. These data are shown of Figure 3-2. Stippled areas on Figures 3-1 and 3-2 indicate paved areas that will not be excavated due to the absence of exposed soil. The Lower Corporation Yard is paved and will not be excavated. The paved areas were paved before DOE started to perform experimental tests in the area.

Soil would also be excavated to a depth of 24 inches in the area proximal to the firing table where PCBs exceeded the PRG in samples collected at 2 ft bgs. Soil will also be excavated to a depth of 36 inches adjacent to location 3SS-850-142 and 3SS-850-136 where PCB concentrations exceeded the PRG to a maximum depth of 32.4 inches (2.7 ft). The extent of this area of deeper removal of subsurface soil is about 76,282 ft^2 (Figure 3-2), resulting in an anticipated additional excavation below grade of 3,184 yd^3 (i.e., 4,776 tons). Of the approximate total 15,000 yd^3 of soil to be excavated, approximately 287 yd^3 (or 431 tons) has PCB contamination levels of greater than 50 mg/kg and 14,690 yd^3 (or 22,035 tons) below concentrations of 50 mg/kg. Soil concentrations in excess of 50 mg/kg would require additional costs for disposal in compliance with the Toxic Substances Control Act (TSCA).

Because recent sampling and analysis indicated that the Building 850 sandpile contains PCB concentrations above the PRG and tritium activities that no longer represent a threat to ground water, the sandpile (460 yd^3) would also be excavated and disposed with the Building 850 soil.

The overall volume of soil to be excavated is estimated to be approximately 15,422 yd^3 (approximate weight of 23,133 tons). A 20% factor was added to the soil volumes to account for "fluffing" as the soil is excavated, resulting in a total volume of 18,432 yd^3.

Because the volume of characterized soil that contains TCDD equivalent concentrations in excess of the PRGs is constrained within the volume of soil that contains PCBs above PRG concentrations, the planned removal and disposal will also remove soils with TCDD equivalent concentrations that exceed the EPA industrial soil PRG (Figure 3-3).

The activities associated with the excavation include the surveying and ground definition of the excavation boundaries and initial depth. Soil would be removed with heavy earth-moving equipment, including backhoes, tracked loaders, and bulldozers. Portions of the area are difficult to access due to steep topography. It is anticipated that traditional shallow surface soil excavators (scrapers) would not be adequate for this application due to the terrain. Wheeled loaders, which are more maneuverable, would be used on the flatter surfaces to pile and load soils. A water truck would be used as needed to control dust during the excavation.

The excavated soil would be placed into Lift-Liners™ and staged/stored in a location approximately 100 yards from Building 850 until the soil is ready to ship offsite. Lift-Liners™ are used for packing, storage, and shipping of waste material. Because the soil is anticipated to contain both uranium and PCB, dioxin, and furan constituents, it would be handled, transported, and disposed as mixed waste at a licensed offsite disposal facility. Each Lift-Liner™ would be managed separately with Quality Assurance documentation, DOE-approved manifests, and certification by the Waste Certification Official. Each Lift-Liner™ would be weighed prior to shipping.

Once excavation is complete, verification sampling and analysis of exposed soil for PCBs, dioxins, and furans would be performed using the methodology approved in the Interim Remedial Design for the Building 850 as outlined in the verification sampling plan presented in Appendix D. PCB concentrations in the soil verification samples will be compared to EPA's industrial PRG of 0.74 mg/kg. The dioxin/furan samples will be composited and the composite Toxicity Equivalent Concentration (TEC) will be compared to the PRG for 2,3,7,8-TCDD of 1.6×10^{-5} mg/kg. If analytical results indicate that PCBs, dioxins, or furan occur in the soil at concentrations in excess of these cleanup standards, additional soil will be excavated until these standards are met. Once analytical data confirm that the concentrations in the surface soils meet cleanup standards, the excavated area would be restored to prevent erosion.

Because there are regulatory thresholds (concentrations) for the acceptance of PCB-bearing waste and concentrations at which such waste requires treatment prior to disposal, soil from selected excavation areas may be sequestered according to measured and anticipated PCB concentrations. Each region would then have a waste profile based on concentrations of PCBs (as well as furans, dioxins, uranium, and metals).

The excavation work would be conducted in accordance with substantive provisions of the National Pollutant Discharge Elimination System (NPDES) requirements for storm water discharges from construction activities to minimize erosion and to prevent enhanced sediment

load from entering ephemeral stream drainages. The hillslopes and flat area adjacent to Building 850 would be returned to a grade that is similar to current conditions and stabilized. After soil excavation is completed, on the hillslopes surrounding the Building 850 Firing Table will be restored and reseeded.

6.3. Alternative 3 – Excavation and Onsite Solidification and Consolidation

The primary components of Alternative 3 include:

1. Engineering, institutional, and land use controls to prevent exposure of humans and ecological receptors to PCBs, dioxins, and furans.

2. Excavation, and onsite solidification and consolidation of contaminated soil and sandpile.

3. Placement of a protective layer or layers to act as a biological barrier that may include cobbles, geogrid, or other suitable material to be determined during the detailed design phase (hereafter referred to as protective layer).

These components are described in Sections 6.3.1 and 6.3.2 below.

The total present-worth cost of Alternative 3 is $2,042,282 based on the excavation of PCB-, dioxin-, and furan-impacted soil, solidification and consolidation of impacted soil to a designated area of Site 300, which is likely to be at Building 850 Upper and Lower Corporation Yards, and placement of a protective layer over the solidified soil to prevent direct contact and inhalation of resuspended soil. Detailed cost estimates for this alternative are presented in Appendix C, Table C-2.

6.3.1. Engineering, Institutional, and Land Use Controls

As part of Alternative 3, engineering, institutional, and land use controls will be implemented as necessary to:

1. Ensure RAOs are achieved.

2. Manage risk and/or hazard by preventing exposure of humans and ecological receptors to PCBs, dioxins, and furans.

The following engineering, institutional, and land use controls will be maintained to prevent exposure to the contaminated soil at the Building 850 Firing Table:

- Prevent inadvertent exposure to contaminated soil at Building 850 by non-authorized personnel by controlling access to Site 300.

- Maintain land use restrictions and control activities in the vicinity of the Building 850 Firing Table until remediation of the PCB-, dioxin-, and furan-contaminated soil and sandpile reduces the risk to onsite workers to less than 10^{-6}.

- Control activities to prevent onsite worker exposure to contaminants in soil during removal action excavation and soil solidification activities. Controls may consist of a combination of engineered controls (e.g., wetting soil during excavation and covering

excavated soil prior to solidification), personal protective equipment, and institutional controls (e.g., preventing access to personnel not involved in removal action), as necessary.

- Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that subsurface soil does not pose an exposure risk to onsite workers.
- Maintain the integrity of the solidified soil as long as it remains in place.
- Inspect for the presence of animals in stockpiled soil prior to solidification.
- Prohibit the transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use until and unless a risk assessment is performed that shows no unacceptable risk for residential or unrestricted land use.

The controls are described in further detail in Table 6-1.

6.3.2. Excavation and Onsite Solidification and Consolidation of Contaminated Soil and Sandpile

Alternative 3 consists of excavating PCB-, dioxin, and furan-contaminated soil, solidification and consolidation at a designated area of Site 300, and placement of a protective layer over the soils to prevent direct contact and inhalation of re-suspended soil. The components of Alternative 3 are presented on Figure 6-2. A cross-section through a portion of the consolidation area is shown in Figure 6-3.

6.3.2.1. Excavation of Contaminated Soil and Sandpile

Impacted soils containing PCBs at concentrations above 0.74 mg/kg would be excavated from areas around Building 850 to depths of up to 3 ft bgs (a total volume of 15,422 yd^3 or 18,432 yd^3 when accounting for the increase in soil volume from "fluffing"). The volume of soil to be excavated under Alternative 3 is the same as for Alternative 2 described in Section 6.2.2. Because the volume of characterized soil that contains TCDD equivalent concentrations in excess of the PRGs is constrained within the volume of soil that contains PCBs above PRG concentrations, the planned removal and solidification will also remediate soils containing the excessive TCDD equivalent concentrations.

The sandpile adjacent to Building 850 will be excavated to the ground surface (approximately 8 ft) and verification sampling will be performed as described below. All excavated material will be solidified and consolidated onsite.

Once excavation is complete, verification sampling and analysis of exposed soil for PCBs, dioxins, and furans would be performed using the methodology approved in the Interim Remedial Design for the Building 850 area as outlined in the verification sampling plan presented in Appendix D. PCB concentrations in the soil verification samples will be compared to EPA's industrial PRG of 0.74 mg/kg. The dioxin/furan samples will be composited and the composite TEC will be compared to the PRG for 2,3,7,8-TCDD of 1.6×10^{-5} mg/kg. If analytical results indicate that PCBs, dioxins, or furan occur in the soil at concentrations in excess of these cleanup standards, additional soil will be excavated until these standards are met.

Once analytical data confirm that the concentrations in the surface soils meet cleanup standards, the excavated area would be restored to prevent erosion. The restoration procedures will be described in the detailed design and may include backfilling the excavated area with purchased or local borrowed soil, terracing and installation of drains, and/or reseeding with native grasses.

The excavation work would be conducted in accordance with substantive provisions of the NPDES requirements for storm water discharges from construction activities to minimize erosion and to prevent enhanced sediment load from entering ephemeral stream drainages. These measures could include the use of fiber rolls, silt fences, and other best management practices to prevent sediment transport, and drainage structures and sedimentation structures to convey, attenuate, and reduce the sediment load of runoff water.

6.3.2.2. Solidification of Contaminated Soil and Sandpile

The excavated soil and sandpile material would be solidified onsite using a pug mill system. The solidification technology would encapsulate the PCB-, dioxin-, and furan-contaminated particles in a concrete-like matrix that would render them unavailable for onsite worker exposure through the dermal contact or inhalation of resuspended particulate pathways, and ecological receptor exposure through inhalation or ingestion pathways, thereby meeting the Removal Action Objectives for this removal action.

The solidification would also add strength to the material so that it could be engineered for a variety of uses including parking or storage. A biological barrier (e.g., a cobble layer) would also be included to provide additional protection against burrowing animals. The final design of the consolidation area will be dependent on the intended use of the area by the LLNL Programs managing the Building 850 facility and/or Site 300 management as described in Section 6.3.2.3.

To determine the most appropriate solidification agent and the amount of solidification agent required, a treatability study was conducted. The study was conducted using representative soil samples collected from several locations in area of surface soil contamination at Building 850. Solidification agents considered in the treatability study consisted of Portland cement, cement kiln dust (CKD), fly ash, and lime. The treatability study was conducted by Conestoga-Rovers & Associates (CRA) at their Treatability Study Laboratory at the CRA Innovative Technology Center in Niagara Falls, New York. A detailed description of the treatability study methods and results is provided in Appendix E. The results of the solidification tests indicated that the Unconfined Compressive Strength (UCS) values were high for all samples tested except the untreated control sample and the sample solidified with 2.5 percent CKD and 2.5 percent lime. The UCS values were greater than 40 pounds per square inch (psi) with the sample treated with 5 percent Portland cement having a UCS of 126 psi and the sample treated with 2.5 percent Portland cement and 2.5 percent CKD having a UCS of 123 psi.

The solidification did not appear to significantly reduce the leachability of the test samples. This may likely be attributed to the low quantities of solidifying reagent and the relatively low leaching observed in the untreated samples. Leaching data for the control sample showed 21 micrograms per liter (μg/L) Aroclor 1254, 0.19 mg/L copper, 0.0017 mg/L cadmium and 0.00058 mg/L beryllium and similar leaching data results were obtained for the samples treated with various quantities of solidification agents.

To determine if the leachability of PCBs and metals could be reduced, a second round of solidification testing was completed with the addition of binding agents (i.e., organic clay, Petroloc®, appropriate binding agent, and activated carbon). The solidification tests were re-run using the two mixes that resulted in a UCS of greater than 100 psi (i.e., 5 percent Portland cement and 2.5 percent Portland cement with 2.5 percent CKD and 1 percent of each of the binding agents).

The results of the additional solidification tests indicate that the binding agents did not have a significant impact on the UCS of the samples. However the organic clay and Petroloc® did reduce the leaching of PCBs by 20 percent and 29 percent, respectively.

In conclusion, the leaching of PCBs in the untreated soil was very low using a standard Toxicity Characteristic Leaching Procedure (TCLP) test that simulates the aggressive leaching conditions of a typical landfill. Therefore, the results of the leaching tests represent a worst case scenario as the site conditions would be more favorable than those simulated by the TCLP test. In addition, the leaching can be decreased by approximately 20 percent through the use of a binding agent. Both the 5 percent Portland cement mix or 2.5 percent Portland cement mix and 2.5 percent CKD mixture resulted in a UCS greater than 100 psi and would be suitable for the strength requirements of the consolidation area. In addition, the strength of both mixes may deter burrowing animals from digging into the consolidated material. However, a protective layer will be included in the final design to ensure animals are not able to come into contact with the solidified soil. Since CKD is less expensive than Portland cement, it is recommended that the 2.5 percent Portland cement and 2.5 percent CKD mix be used for solidification.

6.3.2.3. Consolidation of Solidified Contaminated Soil and Sandpile

The primary proposed onsite consolidation area under consideration for placement of the solidified soil is the Building 850 Upper Corporation Yard, within the area of PCB contamination (Figure 6.2). This area is currently used for equipment storage and parking lot.

Volume calculations have been made to determine the area and height necessary to ensure adequate capacity for the solidified soil at the Upper Corporation Yard (Figures 6-2 and 6-3). The area of the solidified material at this location would be approximately 59,980 ft^2. The disposal area would be a maximum of about 20 ft high. The total volume of soil after solidification is estimated to be about 22,000 yd^3. If the soil does not expand as much as conservatively estimated, the solidified soil may be consolidated within smaller total dimensions.

If, due to soil expansion or requirements to excavate additional soil, the volume of solidified soil is too large to be contained in the footprint of the Building 850 Upper Corporation Yard, it may be necessary to place the remaining solidified soil in the Lower Corporation Yard, which is adjacent to the limit of excavation of PCB-bearing soil.

If the Program utilizing Building 850 retains use of the Upper Corporation Yard area where the consolidated soil would likely be situated, the protective layer may include a combination of an asphalt cover to maintain use of the Corporation Yard for parking and storage with a biological barrier (e.g., a cobble layer) on the sides of the solidified soil to prevent animals from burrowing into the treated soil. The asphalt cover could consist of a minimum of 6 inches of asphalt with approximately 6 inches of granular material beneath the asphalt to support the asphalt and create an additional barrier to prevent burrowing animals for entering the solidified soil mass. The asphalt would be sloped (approximately 2 percent slope) and curbing used to

promote and control storm water drainage. The strength of the solidified material would be sufficient to support the construction of the parking or storage area.

If the LLNL Program utilizing Building 850 decide that they do not want to retain the original use of the Upper Corporation Yard area where the consolidated soil would likely be situated, a protective layer that will act as a biological barrier to burrowing animals will be installed on top of the solidified soil. This layer may include cobbles, geogrid, or other suitable material to be determined during the detailed design phase.

Engineering design considerations and/or Site 300 program activities may require other or additional onsite consolidation areas to be located in other parts of the site (such as on top of the Pit 8 or Pit 9 Landfills). However, DOE/LLNL do not plan to place the solidified soil in uncontaminated areas of Site 300. The regulatory agencies will be consulted prior to the final selection of the solidified soil consolidation location**.**

The most highly contaminated soils would be solidified and consolidated first to minimize the ecological risk of exposure.

Regular inspections of the consolidation area would be made to assess the integrity of the solidification treatment and maintenance/repairs would be conducted as necessary. The remedy will include an annual inspection and maintenance program that will be implemented following completion of the removal action. The primary objective of the inspection and maintenance program will be to ensure that the solidified soil remains competent and that any repairs are made to the protective layer in a timely manner to prevent impacts to ecological receptors. However, in the unlikely event that a breach of the cover system occurs and there is exposure to the underlying solidified soils, the bioavailablity of the material will not result in a significant impact. Monitoring of tritium, nitrate, perchlorate, and uranium concentrations in ground water downgradient of the consolidation area will continue to be conducted in the Building 850 Firing Table area per the requirements of the Compliance Monitoring Plan/Contingency Plan (Ferry, 2002).

Based on the treatability study completed, the unconfined compressive strength values obtained were greater than 100 psi for the recommended solidification agents and thus indicate that the treated material is extremely strong. It is expected that the hardness of the material will deter any animal from ingesting the soil even if the protective layer could be breached. The contaminants would be highly bound up in the cement-sediment matrix and therefore would not readily metabolize. In the unlikely event that a lump of solidified material were to break free and be ingested by an animal, the work of Ghosh et al. (2004) shows that the PCB would likely not be bioavailable and would pass through the gut of an animal without being incorporated into biomass. This work indicates that PCBs that are bound by adsorption to soil organic material pass directly through the guts of benthic invertebrates. It is expected that binding the PCB to the soil matrix with cement will have a similar effect to adsorption of the PCB by organic matter and that the solidified PCB material would not be bioavailable.

In conclusion, even in the most unlikely event that the strength from the solidification were to break down or the protective layer were breached, the inherent strength in the consolidated soils would be sufficiently strong enough to support a variety of potential future land uses.

Regulatory mechanisms exist that allow the management of remediation waste without triggering land disposal restrictions and the associated treatment standards. These mechanisms include the U.S. EPA and DTSC Corrective Action Management Units (CAMUs).

The consolidated soil unit would be managed in accordance with Federal and State Corrective Action Management Unit (CAMU) regulations (40 Code of Federal Regulation [CFR] 264.552 and California Code of Regulations [CCR] Title 22, Section 66264.552). CAMU requirements as they apply to the PCB soil cleanup at Building 850 are as follows:

CAMU designation - 40 Code of Federal Regulation [CFR] 264.552 (b) and California Code of Regulations [CCR] Title 22, Section 66264.552 (e) allows for the designation of a CAMU to enhance implementation of site cleanup.

The Building 850 proposed remedies meet the CAMU designation requirements of 40 CFR 264.552(c) and CCR Title 22, Section 66264.552(c) in that:

(1) The CAMU will facilitate implementation of an effective and protective remedy.

(2) It will not create unacceptable risks to humans or the environment from exposure to hazardous constituents, rather will mitigate these risks.

(3) The CAMU will not include uncontaminated areas of the site.

(4) The CAMU will be managed and contained to minimize future releases.

(5) The CAMU designation will expedite implementation of this removal action.

(6) The soil will be treated to reduce the mobility of contaminants prior to placement.

(7) The design will minimize the land area of the facility upon which waste will remain in place after closure of the CAMU (as discussed in the first paragraph of this section).

DOE/LLNL has provided information to EPA and DTSC for designation of a CAMU consistent with 40 CFR 264.552(d) and CCR Title 22, Section 66264.552(d) including:

(1) A description of the waste origin and the timing and circumstances of release.

(2) Information demonstrating that the waste (soil) was not listed or identified as RCRA hazardous at the time of release.

(3) Information demonstrating that the waste (soil) release occurred before the land disposal requirements of 40 CFR Part 268 were in effect.

Waste requirements - The contaminated soil at Building 850 meets the Federal and State definition of CAMU-eligible waste (solid and RCRA hazardous wastes, and all media [including soils and sediment] that are managed for implementing cleanup [40 CFR 264.552(a)(1) and Title 22 CCR 66264.552(a)(1)(A)].

Land Disposal Restrictions - The Federal and State regulations [40 CFR 264.552(a)(4) and Title 22 CCR 66264.552(a)(4)] state that placement of CAMU-eligible wastes into or within a CAMU does not constitute land disposal of hazardous waste, therefore the RCRA Land Disposal Restrictions do not apply.

Design Requirements - The Federal and State regulations [40 CFR 264.552 (e)(3)(ii)(B) and Title 22 CCR 66264.552(e)(3)(B)] contain provisions for an alternate CAMU design, subject

to approval by EPA and DTSC, and require that the alternate design prevent the migration of any hazardous constituents into ground water at least as effectively as a liner and leachate collection system.

Because PCB leaching is very low in the untreated soil sample, PCBs have low solubility, and there is no current or potential future impacts to ground water from PCBs in Building 850 soil, even without remediation, the soil solidification technology would exceed Federal and State CAMU requirements under 40 CFR 264.552 and CCR Title 22, Section 66264.552 to prevent ground water impacts. The leachability tests conducted on the proposed solidification media mixed with the PCB-contaminated soil confirmed that the solidification process does not adversely affect the solubility or leachability of the PCBs.

The preliminary design for closure and post-closure maintenance activities for the soil consolidation CAMU, and CAMU characteristics per 40 CFR 264.552(e)(6) and CCR Title 22, Section 66264.552(e)(6) provided in this section and Section 6.3.2.3. More specific design and maintenance details would be provided to the regulatory agencies prior to implementation of the removal action. Any post-closure CAMU monitoring requirements as agreed to by DOE and the regulatory agencies would be incorporated into the revised Site-Wide Compliance Monitoring Plan.

Treatment Requirements - Title 40 CFR 264.552 (e)(4)(iv) and Title 22 CCR Section 66264.552 (e)(4) state that CAMU-eligible wastes that EPA and DTSC determine contain principal hazardous constituents shall be treated to achieve a 90% reduction in concentrations or to 10 times the Universal Treatment Standard (UTS) for the principal hazardous constituent.

The NCP establishes an expectation that the lead agency will use treatment to address the principal threats posed by a site wherever practicable. Identifying principal threat wastes combines concepts of both hazard and risk. In general, principal threat wastes are those source materials considered to be highly toxic or highly mobile which generally cannot be contained in a reliable manner or would present a significant risk to human health or the environment should exposure occur. Conversely, non-principal threat wastes are those source materials that generally can be reliably contained and that would present only a low risk in the event of exposure. The manner in which principal threat wastes are addressed generally will determine whether the statutory preference for treatment as a principal element is satisfied. The Interim Record of Decision designated the PCB, dioxin, and furan contaminated surface soil at Building 850 as a principal threat waste. However, while PCBs are toxic, Title 40 CFR 264.552 (e)(4)(i)(A)(1) and 22 CCR Section 66264.552 (e)(4)(A) state that, in general, EPA and DTSC will designate, as a principal hazardous constituent, carcinogens that pose a potential direct risk from ingestion or inhalation at the site at or above 10^{-3}. The baseline risk assessment identified a cancer risk of 5×10^{-4} and 1×10^{-4} to onsite workers for potential inhalation, ingestion, or direct dermal contact with PCBs, and dioxins and furans in contaminated surface soil, respectively. In addition, it has been demonstrated at numerous sites throughout the U.S. that PCB-contaminated soil can be contained in a reliable manner, such as through soil solidification. However, leachability testing conducted on the untreated control soil from Building 850 indicates that PCB (Aroclor 1254) concentrations in the leachate (0.021 mg/L) are less than ten times the 0.10 mg/L Universal Treatment Standard (UTS) for PCBs. Conservatively, the untreated

PCB-bearing soil therefore meets the treatment requirement for CAMU-eligible wastes that the concentrations must be less than 10 times the UTS. Test results for untreated soil also indicate that the TCLP concentrations for beryllium (0.00058 mg/L) and cadmium (0.0017 mg/L) were well below the UTSs of 1.22 mg/L and 0.11 mg/L, respectively. The TCLP concentration for copper in the untreated sample was 0.19 mg/L. There is no UTS (TCLP) concentration for copper. TCLP concentration in treated soils ranged from 0.015 mg/L to 0.024 mg/L for PCBs, less than 0.004 mg/L for beryllium, and from less 0.005 mg/L to 0.0029 mg/L for cadmium. These concentrations are also all well below 10 times the UTS standards. In addition, Title 40 CFR 264.552 (e)(4)(iii)(B) and 22 CCR Section 66264.552 (e)(4)(E) state that U.S. EPA and DTSC may adjust the treatment level or method to a higher or lower level if an adjusted level is protective of human health and the environment, cost effective treatment has been used, and the hazardous constituents in the waste are of very low mobility. PCBs have very low water solubility and tend to readily adsorb to soil.

7. Detailed Evaluation of the Removal Action Alternatives

The National Contingency Plan and the U.S. EPA identify criteria to be used in the detailed evaluation of removal action alternatives, as described in Section 7.1. Sections 7.2 through 7.4 present the evaluation of the three Building 850 surface soil removal action alternatives against these criteria.

7.1. Evaluation Criteria

In accordance with the "Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA" (EPA, 1993), the three removal action alternatives developed in Section 6 for Building 850 were evaluated with respect to four criteria:

1. Effectiveness.
2. Implementability.
3. Cost.
4. State and Community Acceptance.

7.1.1. Effectiveness

The removal action alternatives were evaluated using the EPA guidance criteria for effectiveness including:

- Overall protection of human health and the environment
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction in contaminant toxicity, mobility, and volume.
- Short-term effectiveness.

The first two criteria are the most important since alternatives that do not meet them are not considered viable. Each criterion is described below.

7.1.1.1. Overall protection of human health and the environment

This criterion addresses whether the alternative provides adequate protection of human health and the environment and describes how risks are eliminated, reduced, or controlled through treatment, engineered controls, or institutional controls.

7.1.1.2. Compliance with ARARs

Unless a waiver is obtained, the alternative that is finally selected for remediation of contaminated soils at Building 850 must comply with the ARARs. Table 7-1 presents the ARARs that were approved in the Interim-Site Wide ROD for the remedy selected for the PCB-, dioxin-, and furan-contaminated soil at Building 850 (excavation and offsite disposal), which is presented as Alternative 2 in the EE/CA. Because they have already been approved in the Interim Site-Wide ROD, the ARARs in Table 7-1 are provided for reference only.

Table 7-2 contains potential ARARs for Alternative 3 in the EE/CA (soil excavation, onsite solidification, and consolidation).

7.1.1.3. Long-term Effectiveness and Permanence

This criterion is used to evaluate how each alternative maintains protection of human health and the environment over time once cleanup standards are met.

7.1.1.4. Reduction in Contaminant Toxicity, Mobility, and Volume through Treatment

This criterion is used to evaluate the anticipated ability of an alternative to reduce the toxicity, mobility, and/or volume of contaminants.

7.1.1.5. Short-Term Effectiveness

This criterion addresses the period of time needed to complete the remedy, and any adverse impact on human health and the environment that may be posed during the construction and implementation period. This includes the safety of workers and the public, disruption of site and surrounding land uses, and time necessary to achieve protective measures.

7.1.2. Implementability

This criterion addresses the technical and administrative feasibility of each alternative and the availability of goods and services. Technical feasibility includes the ability of the technology to implement the remedy given site-specific conditions and the reliability of the technology. Administrative feasibility addresses statutory limits, permitting, and siting problems.

7.1.3. Cost

Detailed cost estimates were prepared for the alternatives evaluated in this EE/CA and are presented in Appendix C. The estimates were prepared in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000). Costs

are calculated for both capital expenditures and future operation and maintenance expenses. In accordance with EPA guidance, the cost for the alternatives over time were calculated as present net worth costs to represent the costs in 2007 dollars.

Capital and operation and maintenance costs for each alternative are presented as 2007 present-worth costs using the DOE Office of Management and Budget's 7% discount rate and 3% inflation rate. Total costs for all alternatives were estimated within an accuracy of +50% and -30% in accordance with EPA guidance (U.S. EPA, 2000) and provided for comparison purposes only.

7.1.4. State and Community Acceptance

The California DTSC and RWQCB have reviewed and commented on the removal action alternatives presented in this EE/CA. Analysis of technical and administrative concerns that these agencies may have regarding the alternatives have been addressed. The State agencies will participate in the selection of the removal action remedy in the Action Memorandum.

The community will be provided an opportunity to provide input on the preferred removal action alternative during the public comment period following publication of the Final EE/CA. DOE, EPA, and the State Agencies will review and consider public input in the selection of the Building 850 removal action remedy. Public comments will be addressed in the Responsiveness Summary of the Action Memorandum.

Because state and community acceptance must be evaluated following presentation of the removal action alternatives for input and comment, the alternatives were not evaluated against these criteria at this time.

7.2. Alternative 1: No Further Action

The No Further Action alternative provides a reference against which other alternatives are evaluated. Under this alternative, no action would be taken to contain or remediate contaminated soil at the site.

7.2.1. Overall protection of human health and the environment

Because the soil contamination at Building 850 is wholly contained onsite, site access is restricted, and there are no offsite exposure pathways, the No Further Action Alternative 1 would protect the health of site neighbors and residents in nearby communities.

While institutional controls prevent onsite workers from being exposed to contaminated soil at Building 850, Alternative 1 would not protect onsite workers or burrowing owls at Building 850 in the long-term or meet RAOs because no active measure are taken to mitigate the risk associated with the PCBs, dioxins and furans in surface soil.

7.2.2. Compliance with ARARs

Alternative 1 would not comply with the ARARs as presented in the Interim Site-Wide ROD.

7.2.3. Long-term Effectiveness and Permanence

The No Further Action Alternative 1 would not provide a long-term effective or permanent solution because the soil contamination at Building 850 would remain in place without treatment.

7.2.4. Reduction in Contaminant Toxicity, Mobility, and Volume

Alternative 1 would not reduce the toxicity, mobility, or volume of contamination, because the soil contamination at Building 850 would remain in place without treatment.

7.2.5. Short-Term Effectiveness

There would be no additional short-term risk posed to onsite worker or ecological receptors during implementation of Alternative 1 above that already posed by the contaminated soil as the soil would remain in place undisturbed.

7.2.6. Implementability

The No Further Action alternative would be easy to implement technically and administratively because no active work is included.

7.2.7. Cost

No capital or operations and maintenance (O&M) costs are associated with the No Further Action alternative.

7.3. Alternative 2: Excavation and Offsite Disposal

Alternative 2 consists of excavation and offsite disposal of the PCB-, dioxin-, and furan-contaminated soil in the vicinity of the Building 850 Firing Table and the sandpile to meet soil cleanup standards. A complete description of this alternative is provided in Section 6.2.

7.3.1. Overall protection of human health and the environment

Because the soil contamination at Building 850 is wholly contained onsite, site access is restricted, and there are no offsite exposure pathways, Alternative 2 would protect the health of site neighbors and residents in nearby communities.

Alternative 2 would also protect onsite workers and burrowing owls and meet RAOs as the contaminated soil would be excavated, and transported to an offsite, permitted disposal facility. Excavation with verification sampling will ensure that the soil containing PCBs, dioxins, and furans above the cleanup standards are removed from the site. State-of-the-Art TSCA and Resource Conservation and Recovery Act (RCRA) disposal facilities are conservatively designed and can reliably contain soils contaminated with PCBs, dioxins, and furans to prevent exposure.

7.3.2. Compliance with ARARs

Alternative 2 complies with the ARARs as presented in the Interim Site-Wide ROD.

7.3.3. Long-term Effectiveness and Permanence

Alternative 2 would provide a long-term solution to PCBs, dioxins, and furans in surface soil at Building 850. Removal of the contaminated soil will permanently mitigate the risk to onsite worker and ecological receptors. The public is protected because there is no risk to site neighbors or residents of nearby communities.

7.3.4. Reduction in Contaminant Toxicity, Mobility, and Volume Through Treatment

Alternative 2 would reduce the mobility of the PCBs, dioxins, and furans by removing the contaminated surface soil from Building 850 area where it could be resuspended and inhaled, with subsequent placement in a permitted disposal facility designed to contain the soil and prevent exposure. However, this reduction in mobility would not be accomplished through treatment. The toxicity and volume of the contaminants would not be reduced because the soil would not undergo treatment and would be re-deposited at a different location.

7.3.5. Short-Term Effectiveness

There are short-term risks to workers during implementation of Alternative 2 because workers would be in close proximity to the contaminated soil/sand during excavation and loading activities. However, the use of appropriate heath and safety procedures, and personal protective equipment will minimize the potential risks to workers. This alternative would also require significant trucking of soil to the disposal facilities resulting in the potential for vehicle accidents and atmospheric emissions from internal combustion engines.

7.3.6. Implementability

There are several technical/logistical difficulties associated with the offsite disposal discussed in Alternative 2. It will require 2,204 Lift-Liners™ and 1,102 trucks to relocate the contaminated soil from California to Energy*Solutions* (formerly Envirocare) in Utah to dispose of the 18,432 yd^3 of soil. The trucks would have to traverse windy narrow back-roads to reach the staging location. Alternative 2 could potentially impact the local and regional community and increase risk of traffic incidents by increasing truck traffic to the already congested roadways. Only 4 trucks per day can be reasonably loaded, manifested and shipped. Therefore, Alternative 2 could not be initiated and completed during the summer months of 2008. There are no maintenance activities associated with Alternative 2.

This project is not subject to the statutory limits of $2M or 12 months for conducting non-time critical removal actions; therefore the administrative feasibility of conducting this removal action is not constrained. The soil would be transported to a waste disposal facility that is already permitted to accept this type of material.

Earth moving equipment to excavate the soil and licensed waste haulers transport the soil to offsite disposal facilities are commercially available and competent. However, due to the large number of truck-loads (1,102) required for transport, the availability of sufficient trucks and drivers to accomplish waste removal in a reasonable timeframe is a potential issue. Because the soil would be classified as mixed waste due to the presence of low levels of uranium, the soil must be disposed at a mixed-waste disposal facility which impacts the Nation's limited mixed-waste landfill capacity.

Coordination with ongoing activities in the Building 850 area would be required.

7.3.7. Cost

The cost associated with offsite disposal under Alternative 2 would be on the order of $142 per yd^3 for soil containing less than 50 mg/kg PCBs and $533 per yd^3 for soil containing PCBs greater then 50 mg/kg. The cost to excavate and dispose 18,432 yd^3 of soil would be approximately $8.4M.

7.4. Alternative 3: Excavation and Onsite Soil Solidification

Alternative 3 consists of excavation of PCB-, dioxin-, and furan-contaminated soil in the vicinity of the Building 850 Firing Table and the sandpile to meet soil cleanup standards. The excavated soil will be solidified and consolidated with a protective layer placed over the solidified consolidated material. A complete description of this alternative is provided in Section 6.3.

7.4.1. Overall protection of human health and the environment

Because the soil contamination at Building 850 is wholly contained onsite, site access is restricted, and there are no offsite exposure pathways, Alternative 3 would protect the health of site neighbors and residents in nearby communities.

Alternative 3 would also protect onsite workers and burrowing owls and meet RAOs as the contaminated soil and sand would be excavated and solidified to prevent exposure of human and ecological receptors. Verification sampling will ensure that the soil containing PCBs, dioxins, and furans above the cleanup standards are excavated and solidified. The protective layer will provide additional protection to prevent animals from burrowing into the solidified soil.

7.4.2. Compliance with ARARs

Alternative 3 complies with the ARARs as presented in the Interim Site-Wide ROD.

7.4.3. Long-term Effectiveness and Permanence

Alternative 3 would provide a long-term solution to PCBs, dioxins, and furans in surface soil at Building 850. Removal and solidification of the contaminated soil will permanently mitigate the risk to onsite worker and ecological receptors. The public is protected because there is no risk to site neighbors or residents of nearby communities.

7.4.4. Reduction in Contaminant Toxicity, Mobility, and Volume

Alternative 3 would reduce the mobility of the PCBs, dioxins, and furans by removing the contaminated surface soil from Building 850 area. The soil would then be solidified to prevent exposure to human and ecological receptors. The toxicity and volume of the contaminants would not be reduced.

7.4.5. Short-Term Effectiveness

There are short-term risks to onsite workers during implementation of Alternative 3 because workers would be in close proximity to the contaminated soil during excavation, solidification, and consolidation activities. However, the use of appropriate heath and safety procedures and personal protective equipment will eliminate the potential risks to workers.

7.4.6. Implementability

All of the services and materials required to implement Alternative 3 are commercially available. Appropriate earth moving and solidification equipment and operators are generally available and competent. The protective layer would be constructed of materials that are readily available. Coordination with ongoing activities in the Building 850 area would be required to implement this alternative. An inspection and maintenance program would need to be implemented to ensure the integrity of the solidification treatment is maintained.

This project is not subject to the statutory limits of $2M or 12 months for conducting non-time critical removal actions; therefore the administrative feasibility of conducting this removal action is not constrained. EPA and/or DTSC approval is required to acquire a formal CAMU designation for the solidified, consolidated soil unit.

7.4.7. Cost

The cost associated with solidification in Alternative 3 would be on the order of $108 per yd^3. The cost to excavate 18,432 yd^3 of soil, solidification of the material onsite, consolidation, and construction of a protective layer would be approximately $2.0M.

8. Comparative Evaluation of the Removal Action Alternatives

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for Building 850 surface soil with respect to the NCP and EPA evaluation criteria.

8.1. Overall Protection of Human Health and the Environment

Because the soil contamination at Building 850 is wholly contained onsite, site access is restricted, and there are no offsite exposure pathways, all three alternatives would equally protect the health of site neighbors and residents in nearby communities.

While institutional controls prevent onsite workers from being exposed to contaminated soil at Building 850, the No Further Action Alternative 1 would not protect onsite workers or burrowing owls at Building 850 in the long-term because no active measure are taken to mitigate the risk associated with the PCBs, dioxins and furans in surface soil.

Alternatives 2 and 3 would protect onsite workers and burrowing owls and meet RAOs as the contaminated soil would be excavated, and transported to an offsite, permitted disposal facility (Alternative 2) or solidified and covered with a protective layer to prevent exposure

(Alternative 3). Alternative 3 requires long-term inspection and maintenance to protect the integrity of the protective layer and solidified soil.

8.2. Compliance with ARARs

Alternative 1 would not comply with the ARARs as presented in the Interim Site-Wide ROD. Alternatives 2 and 3 both comply with the ARARs as presented in the Interim Site-Wide ROD.

8.3. Long-term Effectiveness and Permanence

Alternative 1 would not provide a long-term effective or permanent solution because the soil contamination at Building 850 would remain in place without treatment.

Alternatives 2 and 3 both provide a long-term solution to PCBs, dioxins, and furans in surface soil at Building 850. Removal of the contaminated soil will permanently mitigate the risk to onsite worker and ecological receptors. Disposal at a permitted facility designed to contain the contaminated soil under Alternative 2 and onsite solidification and maintenance would prevent future exposure. The public is protected because there is no risk to site neighbors or residents of nearby communities.

8.4. Reduction in Toxicity, Mobility, and Volume

Alternative 1 would not reduce the toxicity, mobility, or volume of contamination, because the soil contamination at Building 850 would remain in place without treatment.

Alternatives 2 and 3 would both reduce the mobility of the PCBs, dioxins, and furans by removing the contaminated surface soil from Building 850 area with subsequent placement in a permitted offsite disposal facility designed to contain the soil (Alternative 2) or onsite solidification to prevent exposure (Alternative 3). Offsite disposal reduces the mobility of soil contaminants, because the soil is removed from the firing table area, where it could be resuspended and inhaled, and is placed in a lined and capped offsite landfill that prevents resuspension of contaminated soil particulates. However, under Alternative 2, this reduction in mobility would not be accomplished through treatment. The toxicity and volume of the contaminants would not be reduced under either Alternative 2 or 3.

8.5. Short-term Effectiveness

There would be no additional short-term risk posed to onsite worker or ecological receptors during implementation of Alternative 1 above the risk already posed by the contaminated soil because the soil would remain in place undisturbed.

There are short-term risks to onsite workers during implementation of Alternatives 2 and 3 because workers would be in close proximity to the contaminated soil. However, the use of appropriate health and safety procedures and personal protective equipment will control and manage the potential risks to workers.

Alternative 2 would require significant trucking of soil to the disposal facilities resulting in the potential for vehicle accidents and atmospheric emissions.

8.6. Implementability

Alternative 1 would be easy to implement technically and administratively because no active work is included.

Alternatives 2 and 3 are both implementable, as earthmoving and solidification equipment and operators, and waste haulers are generally available and competent. Coordination with ongoing activities in the Building 850 area would be required to implement both alternatives. Alternative 2 could potentially impact the local and regional community and increase risk of traffic incidents by increasing truck traffic to the already congested roadways. Only 4 trucks per day can be reasonably loaded, manifested and shipped, therefore it would take considerably longer to implement Alternative 2 than to excavate and consolidate and solidify the soil under Alternative 3. There are no maintenance activities associated with Alternative 2, while Alternative 3 will require long-term inspection and maintenance of the solidified soil and protective layer to ensure integrity.

8.7. Cost

There is no cost to implement Alternative 1 because no remedial action would occur. Alternative 2 has the highest capital costs for implementation at $8,449,922. Alternative 3 is significantly lower in cost ($2,042,282). Alternative 3 would require long-term inspection and maintenance activities to ensure the alternative remains protective and continues to meet the RAOs. These activities include periodic inspections of the solidified soil consolidation area to ensure it is intact and repairs are made, as necessary.

9. Recommended Removal Action Alternative

DOE proposes implementing Alternative 3 described in this EE/CA as a non-time critical removal action. Alternative 3 consists of excavation of PCB-, dioxin-, and furan-contaminated soil in the vicinity of the Building 850 Firing Table and the sandpile to meet soil cleanup standards. The excavated soil will be relocated/consolidated to reduce the impacted area and solidified to reduce human and ecological exposure to contaminated soil and sandpile.

DOE believes that this alternative protects human health and the environment, meets ARARs, and provides the best balance of EPA/NCP evaluation criteria. While both Alternatives 2 and 3 are equally protective of human health and the environment, and meet ARARs, Alternative 2 is four times more expensive due to the high cost of offsite disposal of the soil.

If DOE implements this alternative as a non-time critical removal action, the soil excavation and solidification would be implemented in 2008 after the removal action has been approved via acceptance of the Action Memorandum. The 65% design for the removal action remedy would be submitted to the regulatory agencies prior to field implementation.

10. References

Dibley, V., R. Blake, T. Carlsen, M. Denton, R. Goodrich, S. Gregory, K. Grote, V. Madrid, C. Stoker, M. Taffet, J. Valett (2004a), *2003 Annual Compliance Report for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319).

Dibley, V., R. Blake, T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, J. Valett (2004b), *First Semester 2004 Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-04).

Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, J. Valett (2005a), *2004 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-04).

Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, J. Valett (2005b), *First Semester 2005 Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-05).

Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, D. Mason, P. McKereghan, M. Taffet, J. Valett (2006a), *2005 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-05).

Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, M. Taffet, J. Valett (2006b), *First Semester 2006 Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206769-06).

Dibley, V., T. Carlsen, S. Chamberlain, W. Daily, Z. Demir, M. Denton, R. Goodrich, S. Gregory, V. Madrid, D. Mason, P. McKereghan, M. Taffet, J. Valett (2007), *2006 Annual Compliance Monitoring Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-206319-06).

Ferry, L., R. Ferry, W. Isherwood, R. Woodward, T. Carlsen, Z. Demir, R. Qadir, and M. Dresen (1999), *Final Site-Wide Feasibility Study for Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-132609).

Ferry, R., L. Ferry, M. Dresen, and T. Carlsen (2002), *Compliance Monitoring Plan/Contingency Plan for Interim Remedies at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-147570).

Ferry, L., M. Dresen, Z. Demir, V. Dibley, V. Madrid, M. Taffet, S. Gregory, J. Valett, M. Denton (2006), *Final Site-Wide Remediation Evaluation Summary Report for Lawrence Livermore National Laboratory Site 300,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-220391).

Ghosh, U., G. Luthy, J. Zimmerman, P. MacLeod, S. Smithenry, T. Bridges, and R. Millward (2004) *In Situ Bioavailability of PCBs in Sediments: From Bench-Scale to Field Demonstration*, Remediation Technology Development Forum, Sediment Remediation Action Team Meeting, February 18-19, 2004, Baltimore MD.

Taffet, M., L. Green-Horner, L. Hall, T. Carlsen, and J. Oberdorfer (1996), *Addendum to the Site-Wide Remedial Investigation Report Lawrence Livermore National Laboratory Site 300*: *Building 850/Pit 7 Complex Operable Unit,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-108131 Add. 1).

Taffet, M., V. Dibley, L. Ferry, Daily, Z. Demir, V. Madrid, S. Martins, J. Valett, and S. Bilir (2004), *Interim Remedial Design for the Building 850 Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-201835).

U.S. DOE, (2001), *Interim Site-Wide Record of Decision for Lawrence Livermore National Laboratory, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-138470).

U.S. DOE (2007), *Site-Wide Proposed Plan for the Lawrence Livermore National Laboratory Site 300 Final Record of Decision,* Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-226111).

U.S. EPA (1993), *Guidance on Conducting Non-Time Critical Removal Actions Under CERCLA*, U.S. Environmental Protection Agency, EPA/540-R-93-057.

Van den Burg, M., L. Birnbaum, Albertus T.C. Bosveld, B. Brunström, P. Cook, M. Feeley, J.P. Glesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X. Rolaf van Leeuwen, A.K. Dijien Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tyslind, M. Younes, F. Waern, and T. Zacharewski (1998), "Total Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife," *Environmental Health Perspectives*, **106**(12) 775–792.

Webster-Scholten, C.P., Ed. (1994), *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-108131).

11. Acronyms and Abbreviations

$^{235}U/^{238}U$	Uranium-235/uranium-238 atom ratio
^{238}U	Uranium-238
ARARs	Applicable or relevant and appropriate requirements
bgs	Below ground surface
CAMU	Corrective Action Management Unit
CCR	California Code of Regulations
CDD	Chloro-di-benzo-p-dioxins
CDF	Chloro-di-benzofurans
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CKD	Cement Kiln Dust
COCs	Contaminants of concern
CRA	Conestoga-Rovers & Associates
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
ft	Feet
ft^2	Square feet
FY	Fiscal year
HE	High explosives
HMX	High Melting Explosive
km	Kilometer
LLNL	Lawrence Livermore National Laboratory
M	Million
MCL	Maximum Contaminant Level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mi^2	Square miles
MSL	Mean Sea Level
NPL	National Priorities List
O&M	Operations and maintenance
OU	Operable Unit
PCB	Polychlorinated biphenyls
pCi/g	PicoCuries per gram
pg/g	Picograms per gram (parts per trillion)
PRG	Preliminary Remediation Goal
psi	Pounds per square inch
RAOs	Removal Action Objectives
RCRA	Resource Conservation and Recovery Act
RDX	Research Department Explosive
ROD	Record of Decision

RWQCB	California Regional Water Quality Control Board
SSLs	Soil Screening Levels
SWRI	Site-Wide Remediation Investigation
TCDD	Tetrachloro-di-benzodioxin
TCDF	Tetrachloro-di-benzofuran
TCLP	Toxicity Characteristic Leaching Procedure
TEC	Toxicity Equivalence Concentration
TEF	Toxicity Equivalence Factor
TNT	Trinitrotoluene
TSCA	Toxic Substances Control Act
TTLC	Total Threshold Leaching Concentration
UCS	Unconfined Compressive Strength
yd^2	Square yards
yd^3	Cubic yards
μg/L	Micrograms per liter

Figures

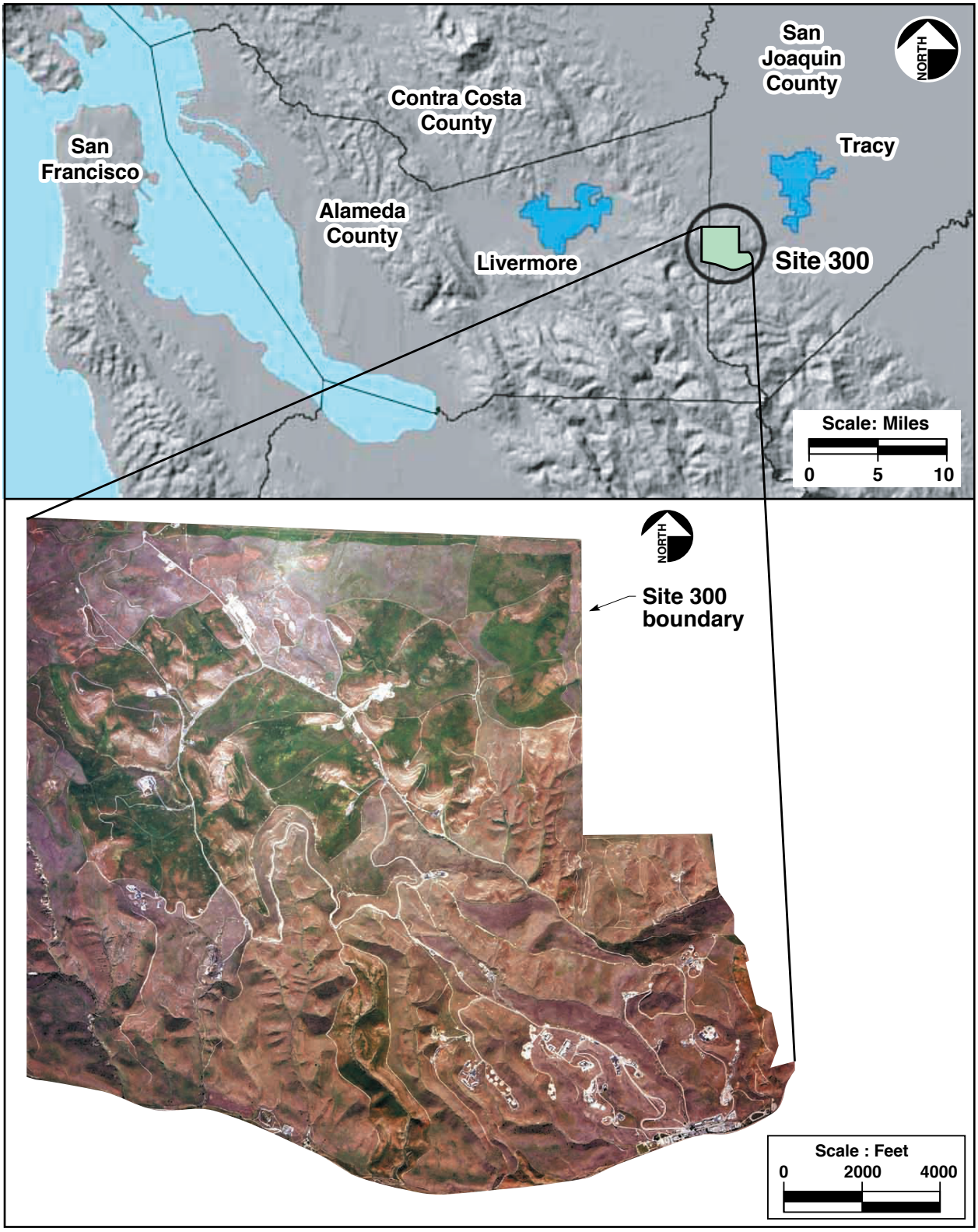


Figure 2-1. Location of LLNL Site 300.

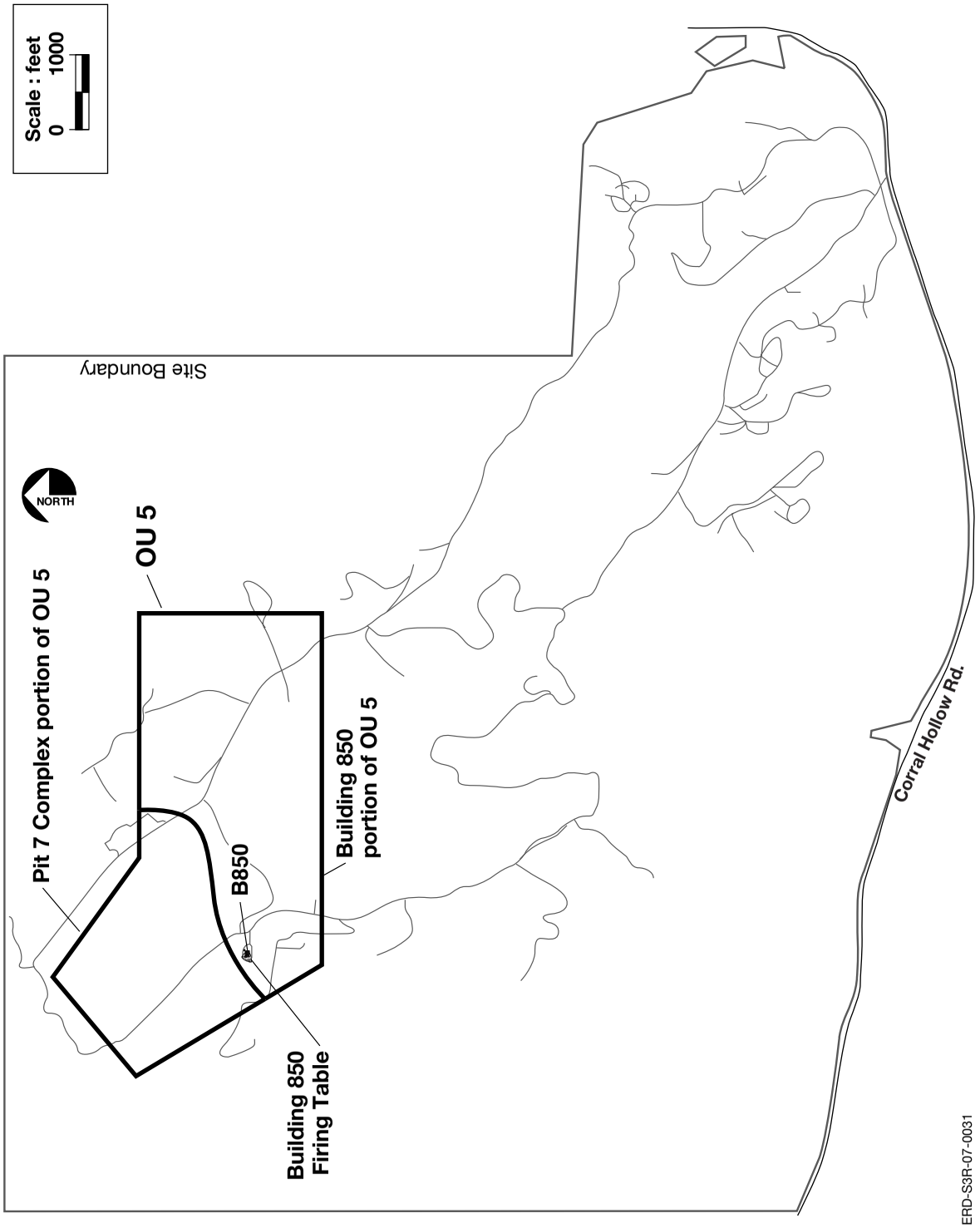


Figure 2-2. Site 300 map showing the location of Operable Unit 5 and the Building 850 Firing Table area.

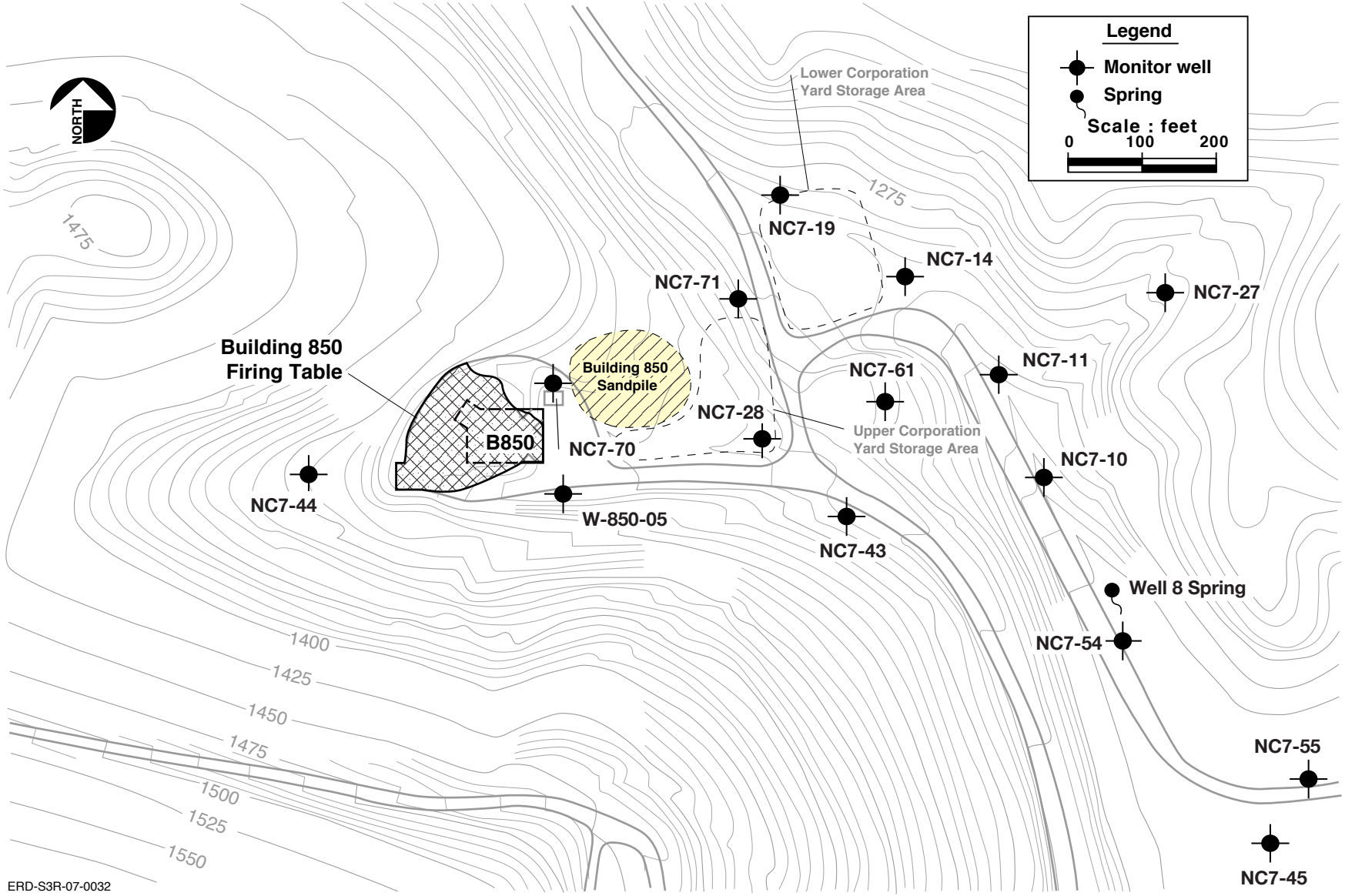


Figure 2-3. Building 850 Firing Table area site map showing topography, buildings, sandpile, and monitor wells.

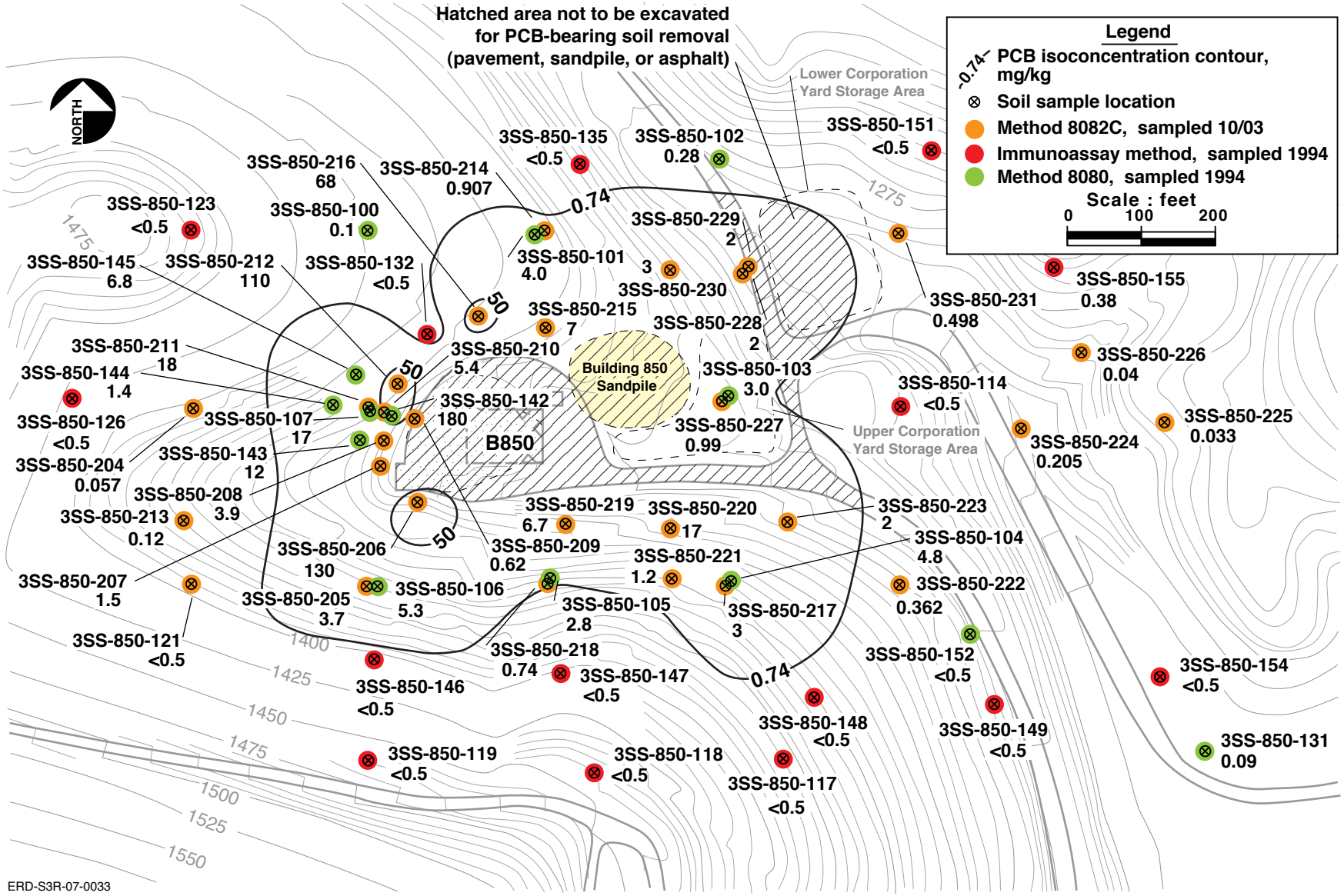


Figure 3-1. Map of the Building 850 (B850) Firing Table and sandpile area delineating areas of surface soil containing polychlorinated biphenyls (PCBs) above 0.74 milligrams per kilogram (mg/kg) and 50 mg/kg.

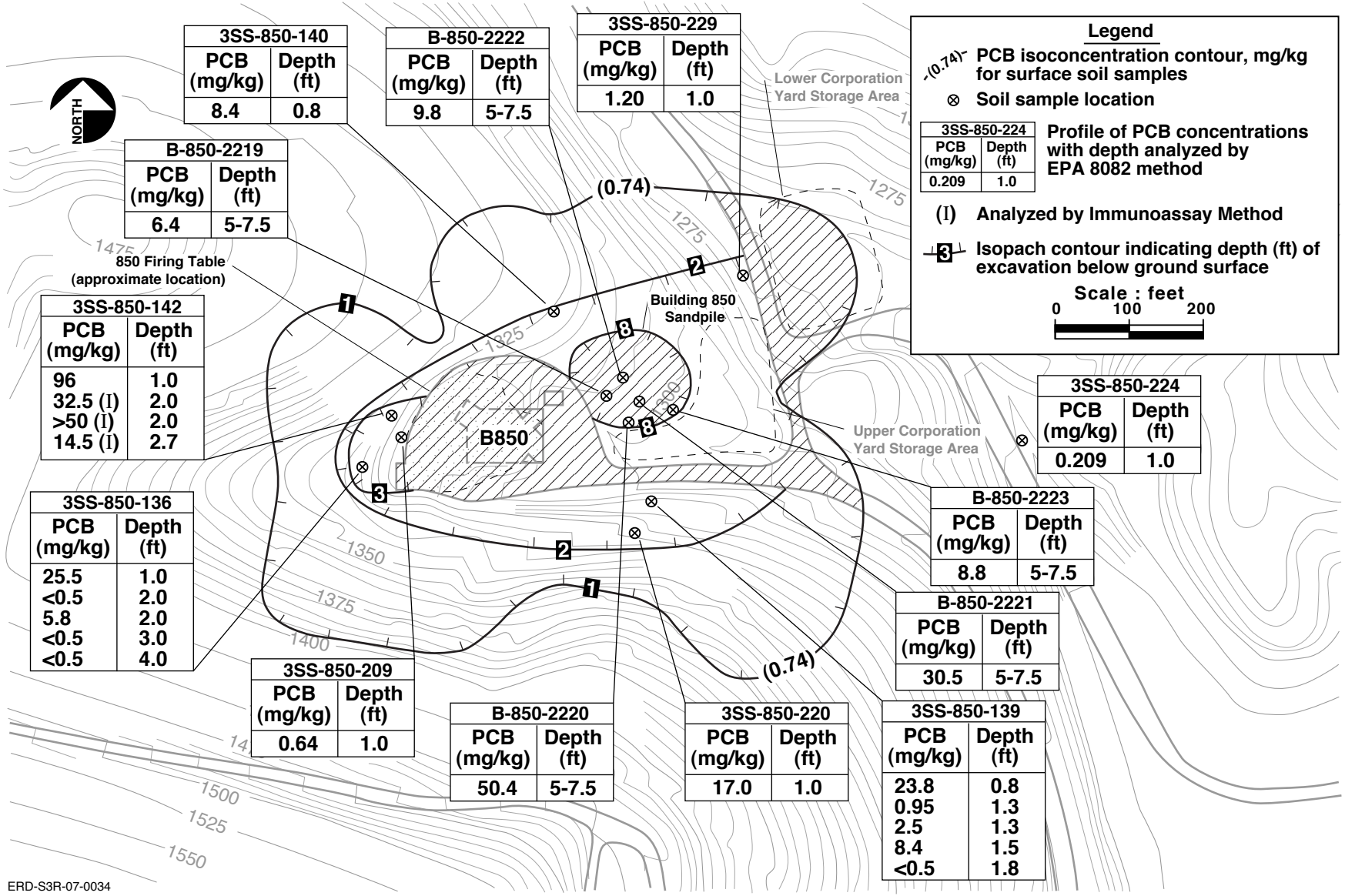
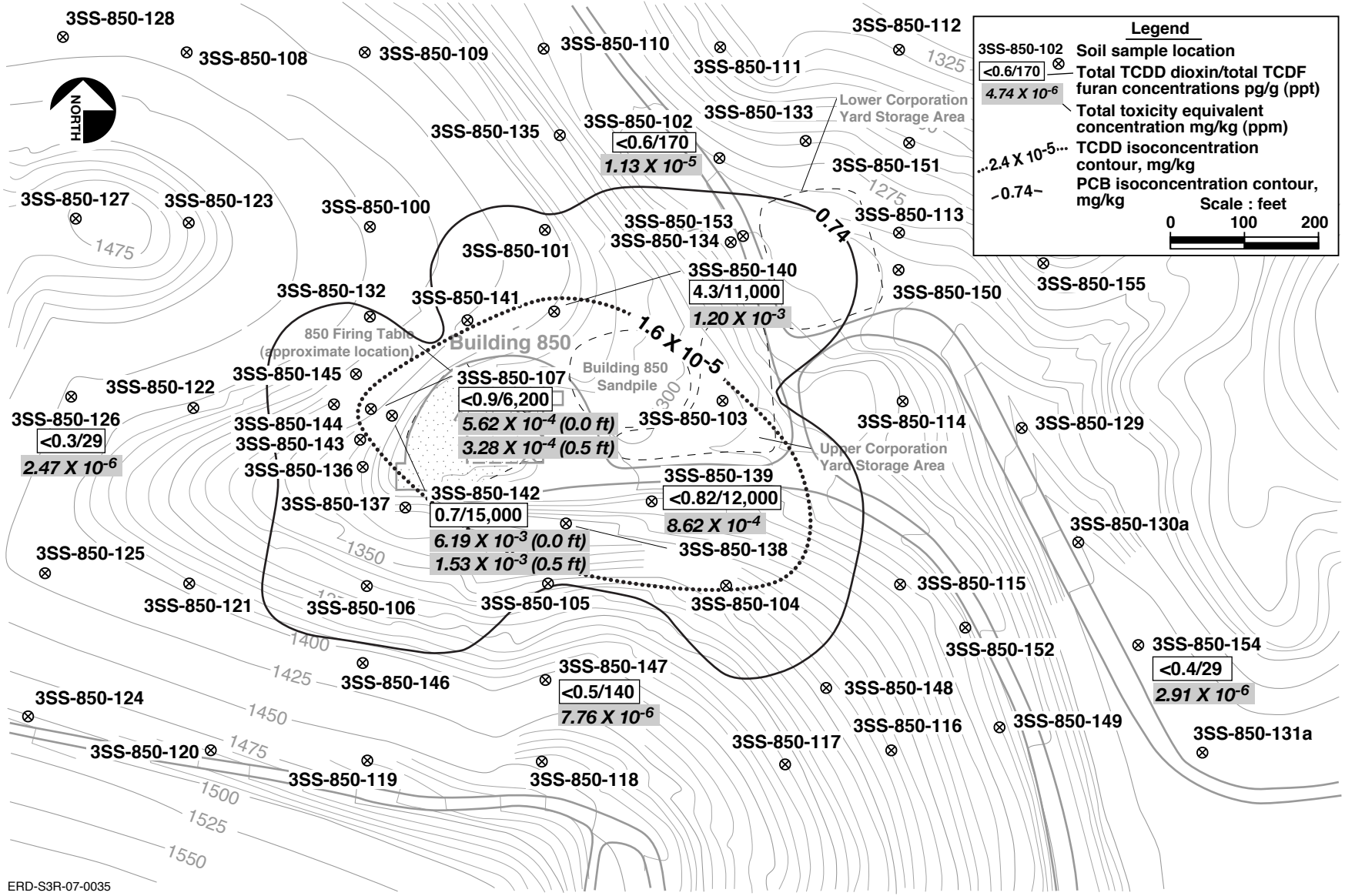


Figure 3-2. Map of the Building 850 Firing Table and sandpile area delineating areas of surface and subsurface soil containing polychlorinated biphenyls (PCBs) above the 0.74 milligrams per kilogram (mg/kg).



ERD-S3R-07-0035

Figure 3-3. Total tetrachloro-di-benzodioxin (TCDD), total tetrachloro-di-benzofuran (TCDF), and total toxicity equivalent factor concentrations in surface soil (0.0 - 0.5 feet [ft]) in the Building 850 Firing Table area (showing preliminary remediation goal [PRG] contours for polychlorinated biphenyls [PCBs] and TCDD).

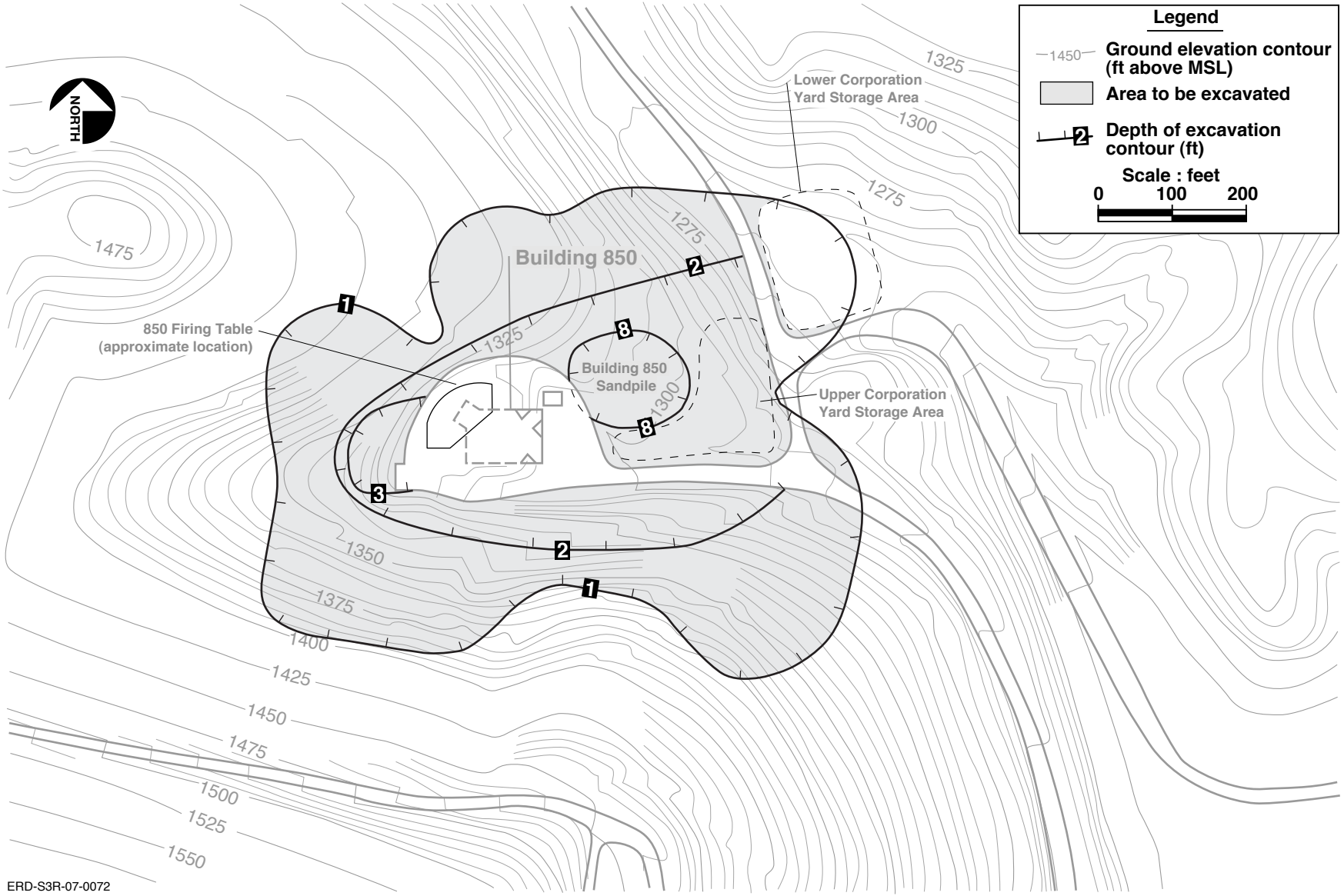


Figure 6-1. Location map for Removal Action Alternative 2 (Excavation and Offsite Disposal).

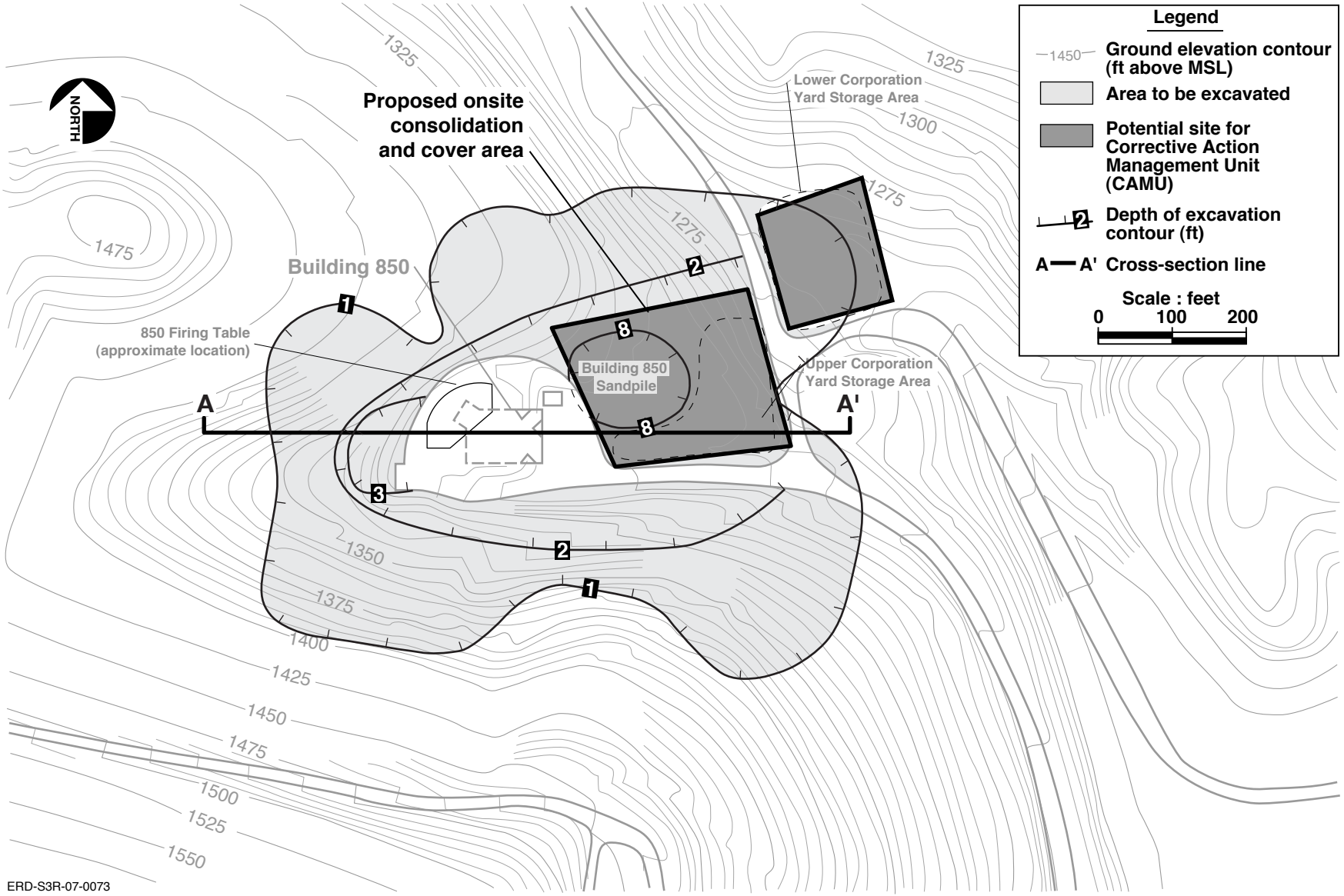


Figure 6-2. Location map for Removal Action Alternative 3 (Excavation and Onsite Soil Solidification).

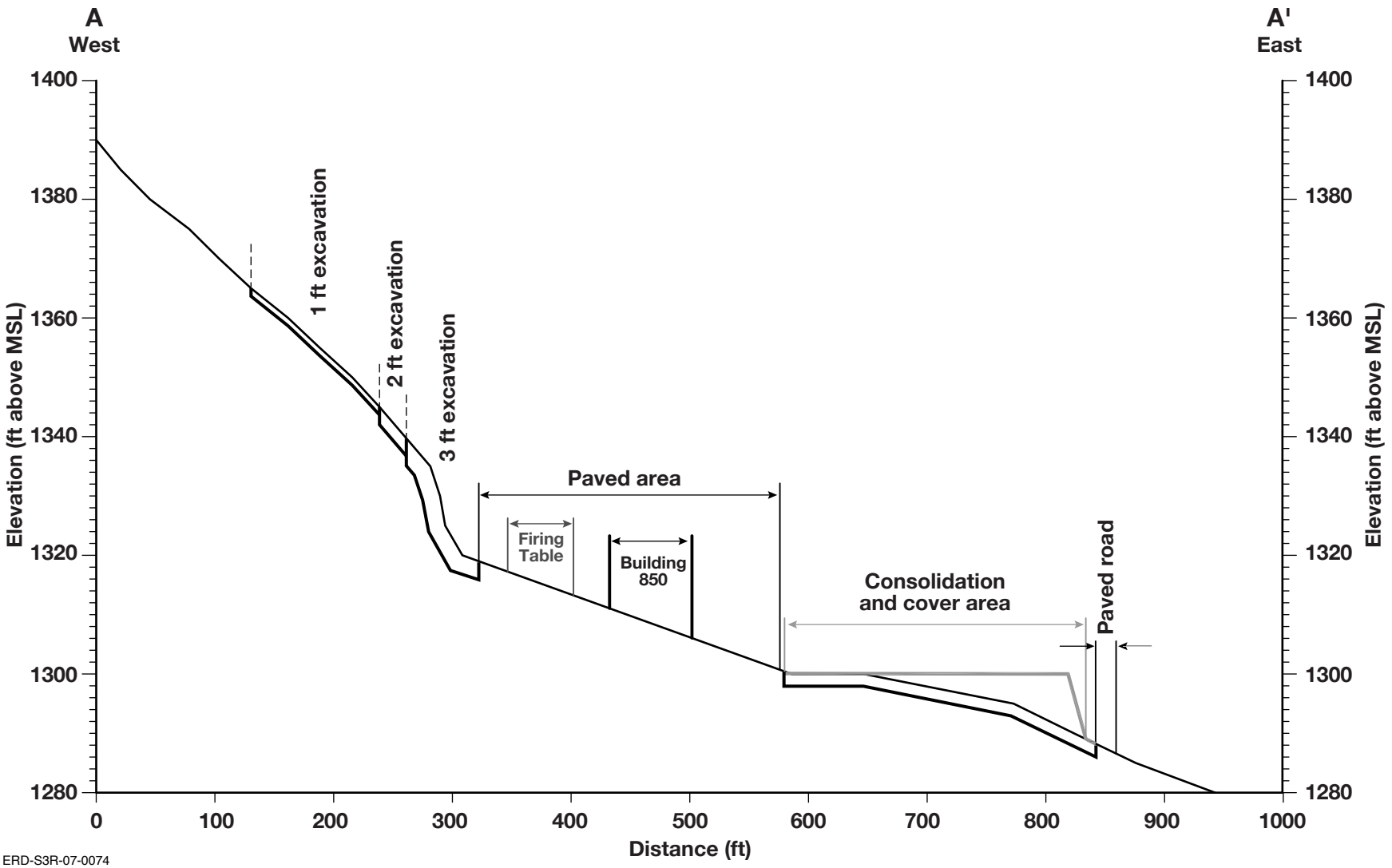


Figure 6-3. Cross-section through Building 850 area for Removal Action Alternative 3 (Excavation and Onsite Soil Solidification).

Tables

Table 4-1. Building 850 Non-Time Critical Removal Action Schedule.

Action	Date
Submit Draft Engineering Evaluation/Cost Analysis (EE/CA)	**August 27, 2007**
Submit Draft Final EE/CA	**January 15, 2008**
Submit Final EE/CA	**February 15, 2008**
Public Workshop	**March 6, 2008**
Submit Action Memo	**April 30, 2008**
Submit 65% Design for the Removal Action Remedy	**To Be Determined**
Initiate Removal Action	**September 30, 2008**

Table 5-1. Preliminary response action and technology screening and evaluation for the Building 850 soil and sandpile.

General Response Action	Remediation Technology Type	Technology (process options)	Screening Comments	Effectiveness	Implementability	Cost	Retained for Further Consideration
No further action	None	Natural decay and degradation.	Applicable	Not effective	Implementable.	None	For comparison only
Risk and hazard management	Institutional controls: Restrict access and use	Fencing and signs.	Applicable	Effective	Currently implemented onsite.	Low	Yes
		Security guards and patrols.	Applicable	Effective	Currently implemented onsite.	Low	Yes
		Onsite activity controls.	Applicable	Effective	Currently implemented onsite.	Low	Yes
		Land use restrictions.	Applicable	Effective	Currently implemented onsite.	Low	Yes
	Ecological hazard controls	Ecological surveys.	Applicable	Effective	Currently implemented onsite.	Low	Yes
In situ physical containment	*In situ* cover placed on contaminated soil to prevent exposure	Placement of Portland cement (concrete) slab overtop granular base.	Applicable	Effective	Difficult to implement due to topographic conditions.	Very high	No
		Placement of asphalt overtop granular base.	Applicable	Effective	Difficult to implement due to topographic conditions.	High	No

Table 5-1. Preliminary response action and technology screening and evaluation for the Building 850 soil and sandpile. (Continued)

General Response Action	Remediation Technology Type	Technology (process options)	Screening Comments	Effectiveness	Implementability	Cost	Retained for Further Consideration
In situ Physical containment *(continued)*	*In situ* cover placed on contaminated soil to prevent exposure *(continued)*	Pre-grading, placement of low permeability clay layer, placement of sand and fill layers, vegetative cover.	Applicable	Effective	Difficult to implement due to topographic conditions.	Low	No
	Synthetic cover	Pre-grading, placement of synthetic cover, placement of sand and fill layers, vegetative cover.	Applicable	Effective.	Difficult to implement due to topographic conditions.	Low	No
In situ treatment	Thermal desorption	Excavate or blanket soil surface, heat soil, recover PCB vapors, replace soils as necessary.	Applicable	Effective.	May not be implementable. Long timeframe to finish remediation. May create secondary hazardous waste. Additional safety controls necessary in dealing with heat, high voltage, and PCB vapors.	Very high	No
	Ozone	Blanket soil surface and inject ozone gas.	Applicable	Possibly effective. Not thoroughly demonstrated in the field.	Implementable.	Medium	No

Table 5-1. Preliminary response action and technology screening and evaluation for the Building 850 soil and sandpile. (Continued)

General Response Action	Remediation Technology Type	Technology (process options)	Screening Comments	Effectiveness	Implementability	Cost	Retained for Further Consideration
In situ treatment *(continued)*	Vitrification	Insert electrodes and apply high voltage to soil zone.	Applicable	Possibly effective. Not thoroughly demonstrated in the field.	May not be implementable. Safety concerns.	Medium	No
Removal and disposal	Excavation	Soil removal.	Applicable	Effective. Increases short-term exposure risk to workers during removal and transport to lay-down area.	Implementable.	Medium	Yes
	Contaminated soil disposal	Offsite disposal.	Applicable	Effective. Increases short-term exposure risk to workers during removal, transport and disposal of excavated soil.	Implementable.	Very High	Yes
Removal and treatment	Excavation	Soil removal.	Applicable	Effective. Increases short-term exposure risk to workers during removal and transport to staging area.	Implementable.	Medium	Yes

Table 5-1. Preliminary response action and technology screening and evaluation for the Building 850 soil and sandpile. (Continued)

General Response Action	Remediation Technology Type	Technology (process options)	Screening Comments	Effectiveness	Implementability	Cost	Retained for Further Consideration
Removal and treatment *(continued)*	Solvent extraction	Solvent washing removes PCBs into liquid phase that can be separated from soil.	Applicable	Effective. Increases short-term exposure risk to workers during soil treatment.	Implementable. Return treated soil to original location. Long timeframe to finish remediation. Solvent may create secondary hazardous waste.	Very high	No
	Solvated electron treatment	Solvent reactor/distillation.	Applicable	Effective. Increases short-term exposure risk to workers during soil treatment.	Implementable. Return treated soil to original location. Solvent may create secondary hazardous waste.	Very high	No
	Soil solidification	Mix surface soils with cement, fly ash, lime, or other agents and dispose onsite.	Applicable	Effective. Increases short-term exposure risk to workers during soil treatment and onsite disposal.	Implementable. May need to consolidate solidified soil outside of Building 850 area due to possible impacts from ongoing site operations.	Low	Yes
	Chemical dehalogenation: Base-catalyzed decomposition process (BCDP)	Soil is crushed and mixed with sodium bicarbonate and heated. Majority of PCBs are broken down. Remaining PCBs are captured and decomposed in additional steps.	Applicable	Possibly effective. Not well-developed for PCBs.	Implementable. Additional safety controls necessary in dealing with heat, solvents, and PCB vapors.	Very High	No

Table 5-1. Preliminary response action and technology screening and evaluation for the Building 850 soil and sandpile. (Continued)

General Response Action	Remediation Technology Type	Technology (process options)	Screening Comments	Effectiveness	Implementability	Cost	Retained for Further Consideration
Removal and treatment *(continued)*	Mechano-Chemical Destruction (MCD)	Mix soil with sand and a proprietary metal-bearing reagent in a ball mill. PCBs break down to simple inorganic molecules and carbon.	Applicable	Possibly effective. Not well-developed for PCBs.	Implementable. Additional safety controls necessary in dealing with solvents.	Very High	No
	Biodegradation	Mix soil with reagent. Biologically mediated reaction occurs in windrows.	Applicable	Possibly effective. Not well-developed for PCBs.	Implementable.	Medium	No

Notes:

PCBs = Polychlorinated biphenyls.

Costs:

Low = < 1 million dollars.
Medium = Between 1 and 2 million dollars.
High = Between 2 and 4 million dollars.
Very High = > 4 million dollars.

Table 6-1. Engineering, institutional, and land use controls for the Building 850 Removal Action.

Engineering, institutional, and land use control performance objective and duration	Risk necessitating institutional/land use control	Engineering, institutional, and land use controls and implementation mechanism
Control excavation activities to prevent onsite worker exposure to contaminants in subsurface soil until it can be verified that subsurface soil does not pose an exposure risk to onsite workers.	Potential exposure to tritium and depleted uranium at depth in subsurface soil at the Building 850 Firing Table[a], and to PCBs that could be contained in soil below the asphalt in the vicinity of Building 850[b].	All proposed excavation activities must be cleared through LLNL Work Induction Board and require an excavation permit. The Work Induction Board coordinates with the LLNL Environmental Restoration Division to identify if there is a potential for exposure to contaminants in the proposed construction areas. If a potential for contaminant exposure is identified, the LLNL Site 300 Hazards Control Department ensures that hazards are adequately evaluated and necessary controls identified and implemented prior to the start of work. The Work Induction Board including the LLNL Environmental Analyst will also work with the Program proposing the construction project to determine if the work plans can be modified to move construction activities outside of areas of contamination.
Maintain the integrity of the solidified soil as long as it remains in place.	Potential exposure to PCBs, and dioxin and furan compounds in soil.	DOE will inspect and maintain the solidified soil. Cover and solidified soil maintenance and inspection requirements will be included in the revision to the Site-Wide Compliance Monitoring Plan/Contingency Plan for LLNL Site 300.
Maintain land use restrictions in the vicinity of Building 850 Firing Table until remediation of PCB-, dioxin-, and furan-contaminated soil reduces the risk to onsite workers to less than 10^{-6}.	5×10^{-4} and 1×10^{-4} risk for onsite workers from potential inhalation or ingestion of resuspended particulates and dermal contact with PCBs, and dioxin and furan compounds in surface soil at the Building 850 Firing Table, respectively.	Current activities in the vicinity of the Building 850 Firing Table are well below the exposure scenario for which the unacceptable exposure risk was calculated, which assumed a worker would spend 8 hours a day, five days a week for 25 years on the firing table. Any significant changes in activities conducted in the Building 850 Firing Table must be cleared through LLNL Work Induction Board. The Work Induction Board coordinates with the LLNL Environmental Restoration. Inadvertent exposure of non-authorized personnel to contaminated soil at Building 850 is prevented by controlling access to Site 300. Because the soil contamination at Building 850 is wholly contained onsite, site access is restricted, and there are no offsite exposure pathways, Alternative 2 would protect the health of site neighbors and residents in nearby communities.
Control activities to prevent onsite worker exposure to contaminants in soil during removal action implementation.	Potential exposure of workers during excavation, handling, and transport or soil solidification activities.	Controls may consist of a combination of engineered controls (e.g., wetting soil during excavation and covering excavated soil prior to offsite transport), personal protective equipment, and preventing site access to personnel not involved in removal action, as necessary.

Table 6-1. Engineering, institutional, and land use controls for the Building 850 Removal Action. (Continued)

Engineering, institutional, and land use control performance objective and duration	Risk necessitating institutional/land use control	Engineering, institutional, and land use controls and implementation mechanism
Inspect for the presence of animals in stockpiled soil prior to solidification.	Potential exposure of animals to contaminated environmental media.	Prior to solidification, the LLNL wildlife biologist will conduct a survey of the excavated soil to locate any threatened or endangered species that may be using the staged soil as habitat. If such animals are found, they will be re-located to an undisturbed area. Stockpiled soil will be covered during staging to reduce the potential for animals to burrow into it.
Prohibit transfer of lands with unmitigated contamination that could cause potential harm under residential or unrestricted land use.	Potential exposure to contaminated environmental media.	The Site 300 Federal Facility Agreement contains provisions that assure that DOE will not transfer lands with unmitigated contamination that could cause potential harm. In the event that the Site 300 property is transferred in the future, DOE will execute a land use covenant at the time of transfer in compliance with Title 22 California Code of Regulations, Division 4.5, Chapter 39, Section 67391.1. Development will be restricted to industrial land usage. These restrictions will remain in place until and unless a risk assessment is performed in accordance with then current U.S. EPA risk assessment guidance and is agreed by the DOE, the U.S. EPA, DTSC, and the RWQCB as adequately showing no unacceptable risk for residential or unrestricted land use. These restrictions will be incorporated into the LLNL Site 300 Integrated Strategic Plan or other appropriate institutional planning document.

Notes:

DOE = United States Department of Energy
DTSC = California Department of Toxic Substances Control
U.S. EPA = United States Environmental Protection Agency
LLNL = Lawrence Livermore National Laboratory
PCB = Polychlorinated biphenyl
RWQCB = California Regional Water Quality Control Board

[a] **Risk for onsite worker exposure to tritium and depleted uranium at depth in subsurface soil during excavation activities was not calculated as this was not considered a long-term exposure scenario. As a result, land use controls based on the potential exposure to tritium and depleted uranium in subsurface soil during excavation/construction activities conservatively assume that the tritium and depleted uranium in subsurface soil may pose a risk to human health.**

[b] **The asphalt in the Building 850 area was in place at the time that the PCB-contamination occurred and has been routinely repaved, and PCBs have low mobility, therefore there is minimal potential for contamination of the soil underlying the pavement and there is no current exposure pathway. However, because soil sampling has not occurred beneath the asphalt, the institutional control will ensure that any future excavation beneath the asphalt or asphalt removal is accompanied by sampling and PCB analysis to verify that PCBs are not present beneath the asphalt and to avoid future exposure.**

Table 7-1. Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 2 (soil excavation and offsite disposal)[a].

Action(s)	ARAR Source	Description	Comments
Disposition of waste	***State*:** **California Health and Safety Code, Division 20, Chapter 6.5, CCR, Title 22, Division 4.5, Chapters 11 and 12: Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes** **(Applicable, action-specific)**	**Controls hazardous wastes from point of generation through accumulation, transportation, treatment, storage, and ultimate disposal.**	**Applies to excavated contaminated soil.**
	***State*:** **Title 23, CCR, Division 3, Chapter 15** **(Applicable, action-specific)**	**Regulates hazardous wastes which are discharged to land.**	**Wastes classification system will be used as a basis for determining which wastes may be discharged at each class of waste management unit. Standards for the handling of hazardous waste will be met.**
	***State*:** **Title 27, CCR, Division 2 Subdivision 1** **(Applicable, action-specific)**	**Regulates the disposal of designated waste, municipal solid waste and inert waste.**	**Waste and site classifications and waste management requirements will be applied for solid waste storage or disposal on land.**
Closure	***Federal:*** **Resource Conservation and Recovery Act (RCRA) 40 CFR 264.11-120** ***State:*** **22 CCR 66264.11-120**	**Requires a facility be closed in a manner that minimizes the need for further maintenance and is protective of human health and the environment.**	**Any facility closures meet the requirements of RCRA.**
Storm water controls	***Federal:*** **40 CFR Parts 122, 123, 124, National Pollution Discharge Elimination System, implemented by California Storm Water Permit for Industrial Activities, State Water Resources Control Board Order No. 97-03-DWQ** **(Applicable, action-specific)**	**Regulates pollutants in discharges of storm water associated with hazardous waste treatment, storage, and disposal facilities, wastewater treatment plants, landfills, land application sites, and open dumps. Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards.**	**Applies to storm water discharges from industrial areas. Includes measures to minimize and/or eliminate pollutants in storm water discharges and monitoring to demonstrate compliance.**

Table 7-1. Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 2 (soil excavation and offsite disposal)[a]. (Continued)

Action(s)	ARAR Source	Description	Comments
Storm water controls *(continued)*	***Federal:*** **40 CFR Parts 122, 123, 124, National Pollution Discharge Elimination System, implemented by State Water Resources Control Board Order No. 99-08 DWQ** **(Applicable, action-specific)**	**Regulates pollutants in discharges of storm water associated with construction activity (clearing, grading, or excavation) involving the disturbance of 5 acres or more. Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards.**	**Applies to construction areas over one acre or more in size. Includes measures to minimize and/or eliminate pollutants in storm water discharges and monitoring to demonstrate compliance. Projects meeting the disturbance threshold will develop project-specific construction Storm Water Pollution Prevention Plans.**
Protection of endangered species	***Federal:*** **Endangered Species Act of 1973, 16 USC Section 1531 et seq. 50 CFR Part 200, 50 CFR Part 402 [40 CFR 257.3-2]** **(Applicable, location-specific)**	**Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. NEPA implementation requirements may apply.**	**Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.**
	State: **California Endangered Species Act, California Department of Fish and Game Sections 2050-2068** **(Applicable, location-specific)**	**Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.**	**Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.**

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
CCRs = California Code of Regulations
CFRs = Code of Federal Regulations
EE/CA = Engineering Evaluation/Cost Analysis
NEPA = National Environmental Policy Act
PCBs = Polychlorinated biphenyls
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision

[a] **These ARARs were approved in the Interim Site-Wide Record of Decision (ROD) for the remedy selected for the PCB-, dioxin-, and furan-contaminated soil at Building 850 (soil excavation and offsite disposal, which is presented as Alternative 2 in the EE/CA. Because they have already been approved in the Interim Site-Wide ROD, these ARARs are provided for reference only.**

Table 7-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 3 (soil excavation, solidification, and consolidation).

Action(s)	ARAR Source	Description	Comments
Remediation of PCB-contaminated soil at Building 850	***Federal:*** **40 CFR 761.61(a)(1)(ii)** **(Applicable, action-specific)**	**Federal implementing regulations for PCB waste under Toxic Substances Control Act (TSCA).**	**While the PCB-contaminated soil at Building 850 meets the definition of bulk PCB remediation wastes under the Federal regulations, 40 CFR 761.61(a)(1)(ii) states that "the self-implementing cleanup provisions shall not be binding upon cleanups conducted under other authorities, including but not limited to actions conducted under Section 104 or 106 of CERCLA." The cleanup actions at LLNL Site 300 are conducted under Section 104 of CERCLA.**
Placement of contaminated soil from Building 850 in a Corrective Action Management Unit (CAMU)	***Federal:*** **40 CFR 264.552(a)(1)** ***State:*** **Title 22, CCR, 66264.552(a)(1)(A)]** **(Applicable, action-specific)**	**Defines CAMU-eligible waste as solid and RCRA hazardous wastes, and all media (including soils and sediment) that are managed for implementing cleanup.**	**The contaminated soil at Building 850 meets the Federal and State definition of CAMU-eligible waste.**
	Federal: **40 CFR 264.552(a)(4)** ***State:*** **Title 22, CCR, 66264.552(a)(4)** **(Applicable, action-specific)**	**Placement of CAMU-eligible wastes into or within a CAMU does not constitute land disposal of hazardous waste, therefore the RCRA Land Disposal Restrictions [40 CFR 264.552(a)(4) and Title 22 CCR 66264.552.5(a)(1)] do not apply.**	**Because the PCB-contaminated soil at Building 850 are a CAMU-eligible waste, placement of the solidified soil into a CAMU does not constitute land disposal of hazardous waste and the RCRA Land Disposal Restrictions do not apply.**
	Federal: **40 CFR 264.552 (b)** ***State:*** **Title 22 CCR, Section 66264.552 (e)** **(Applicable, action-specific)**	**Allows for the designation of a CAMU to enhance implementation of site cleanup.**	**The PCB-contaminated soil at Building 850 will be solidified to mitigate the ingestion and inhalation risk to onsite workers and consolidated into a CAMU.**

Table 7-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 3 (soil excavation, solidification, and consolidation). (Continued)

Action(s)	ARAR Source	Description	Comments
Placement of contaminated soil from Building 850 in a CAMU (*continued*)	***Federal:*** **40 CFR 264.552(c) (1-7)** ***State:*** **CCR Title 22, Section 66264.552(c) (1-7)** **(Applicable, action-specific)**	**The cleanup action must meet the CAMU-designation requirements.**	**The designation of a CAMU for the Building 850 soil removal action will: (1) facilitate implementation of an effective and protective remedy, (2) not create unacceptable risks to humans or the environment, (3) not include uncontaminated areas of the site, (4) be managed and contained to minimize future releases, (5) expedite implementation of this removal action, (6) meet treatment requirements, and (7) designed to minimize the land area of the facility upon which waste will remain in place after closure of the CAMU.**
	Federal: **40 CFR 264.552(d)** ***State:*** **Title 22 CCR, Section 66264.552(d)** **(Applicable, action-specific)**	**Requires submittal of information to EPA and DTSC to support the designation of a CAMU.**	**DOE/LLNL has provided information to EPA and DTSC including: (1) a description of the waste origin and the timing and circumstances of release, (2) information demonstrating that the waste (soil) was not listed or identified as RCRA hazardous at the time of release, and (3) information demonstrating that the waste (soil) release occurred before the land disposal requirements of 40 CFR Part 268 were in effect.**
	Federal: ***40 CFR 264.552 (e)(3)(ii)(B)*** ***State:*** **Title 22, CCR, 66264.552(e)(3)(B)]** **(Applicable, action-specific)**	**The regulations contain provisions for an alternate CAMU design, subject to approval by EPA and DTSC, and require that the alternate design prevent the migration of any hazardous constituents into ground water at least as effectively as a liner and leachate collection system.**	**Since there is no potential for impacts to ground water from PCBs in Building 850 soil, even without remediation, the soil solidification technology would exceed Federal and State CAMU requirements under 40 CFR 264.552 and CCR Title 22, Section 66264.552 to prevent ground water impacts.**

Table 7-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 3 (soil excavation, solidification, and consolidation). (Continued)

Action(s)	ARAR Source	Description	Comments
Placement of contaminated soil from Building 850 in a CAMU (*continued*)	***Federal:*** **Title 40 CFR 264.552 (e)(4)(iv)** ***State:*** **Title 22 CCR Section 66264.552 (e)(4)**	**Requires that CAMU-eligible wastes that EPA and DTSC be treated to achieve a 90% reduction in concentrations or to 10 times the Universal Treatment Standard (UTS) for the principal hazardous constituent.**	**Leachability testing conducted on the untreated control soil from Building 850 indicates that PCB and metals concentrations are below 10 times the UTS standards.**
	Federal: **40 CFR 264.552(e)(6)** ***State:*** **Title 22 CCR, Section 66264.552(e)(6)** **(Applicable, action-specific)**	**Contains closure and post-closure requirements for CAMUs.**	**The preliminary design for closure and post-closure maintenance activities for the solidified soil consolidation is provided in the EE/CA. More specific design and maintenance details would be provided to the regulatory agencies prior to implementation of the removal action. Any post-closure monitoring requirements, as agreed to by DOE and the regulatory agencies, would be incorporated into the revised Site-Wide Compliance Monitoring Plan.**
Closure/Construction of soil consolidation waste management unit	***State:*** **Title 27, Sections 21090(b) and 21142** **(Relevant and appropriate, action-specific)**	**Final grading requirements for a waste management unit.**	**The solidified soil CAMU will be designed and maintained such that the final grading will reduce impacts to health and safety.**
	State: **Title 27, Section 21145** **(Relevant and appropriate, action-specific)**	**Final slope stability requirements including slope stability analyses.**	**The solidified soil CAMU will be designed and maintained to meet slope stability requirements.**
	State: **Title 27, Section 21150** **(Relevant and appropriate, action-specific)**	**Drainage and erosion control requirements.**	**The solidified soil CAMU will be designed to meet drainage and erosion control requirements.**

Table 7-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 3 (soil excavation, solidification, and consolidation). (Continued)

Action(s)	ARAR Source	Description	Comments
Post-closure	***State:*** **Title 27, Section 21180(a) and 21090(c)(1)** **(Relevant and appropriate, action-specific)**	**Post closure maintenance requirements.**	**The solidified soil CAMU will be maintained to protect the integrity of the removal action and reduce impacts to health and safety, and security of the site.**
Storm water controls	***Federal:*** **40 CFR Parts 122, 123, 124, National Pollution Discharge Elimination System, implemented by California Storm Water Permit for Industrial Activities, State Water Resources Control Board Order No. 97-03-DWQ.** **(Applicable, action-specific)**	**Regulates pollutants in discharges of storm water associated with hazardous waste treatment, storage, and disposal facilities, wastewater treatment plants, landfills, land application sites, and open dumps. Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards.**	**Applies to storm water discharges from the Building 850 CAMU area. Includes measures to minimize and/or eliminate pollutants in storm water discharges and monitoring to demonstrate compliance.**
	Federal: **40 CFR Parts 122, 123, 124, National Pollution Discharge Elimination System, implemented by State Water Resources Control Board Order No. 99-08 DWQ** **(Applicable, action-specific)**	**Regulates pollutants in discharges of storm water associated with construction activity (clearing, grading, or excavation) involving the disturbance of 5 acres or more. Requirements to ensure storm water discharges do not contribute to a violation of surface water quality standards.**	**Applies to construction areas over one acre or more in size. Includes measures to minimize and/or eliminate pollutants in storm water discharges and monitoring to demonstrate compliance. Projects meeting the disturbance threshold will develop project- specific construction Storm Water Pollution Prevention Plans.**
Protection of endangered species	***Federal:*** **Endangered Species Act of 1973, 16 USC Section 1531 et seq. 50 CFR Part 200, 50 CFR Part 402 [40 CFR 257.3-2]** **(Applicable, location-specific)**	**Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. NEPA implementation requirements may apply.**	**Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.**

Table 7-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 3 (soil excavation, solidification, and consolidation). (Continued)

Action(s)	ARAR Source	Description	Comments
Protection of endangered species (*continued*)	***State:*** **California Endangered Species Act, California Department of Fish and Game Sections 2050-2068** **(Applicable, location-specific)**	**Requires that facilities or practices not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.**	**Prior to any well installation, facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.**
Land use	***State:*** **Hazardous Waste Property (22 CCR 67391.1 e)** **(Relevant and appropriate, action-specific)**	**Prohibits the federal government from transferring land where hazardous substances remain at levels that do not allow unrestricted use of the land, unless a land use covenant or other institutional control is used to ensure that future land use will be compatible with the levels of remaining hazardous materials.**	**Would apply in the event that DOE transfers property at Site 300 to another owner.**
	State: **California Water Code Section 13307.1(c)** **(Applicable, action-specific)**	**Requires that a land use restriction for property not suitable for unrestricted use be recorded pursuant to Section 1471 of the Civil Code.**	**Applicable to closure of waste management units.**
	State: **Title 27, Section 21190(a)(1) and (2); and (b)** **(Relevant and appropriate, action-specific)**	**Post-closure land use requirements.**	**Post-closure land uses will protect health and safety, prevent damage to structures, roads, and utilities, and prevent public contact with the waste.** **The CAMU will be designed to address site land use.**

Notes appear on the following page.

Table 7-2. Potential Applicable or Relevant and Appropriate Requirements (ARARs) for Alternative 3 (soil excavation, solidification, and consolidation). (Continued)

Notes:

ARARs = Applicable or Relevant and Appropriate Requirements
CAMU = Corrective Action Management Unit
CCRs = California Code of Regulations
CFRs = Code of Federal Regulations
DOE = U.S. Department of Energy
EE/CA = Engineering Evaluation/Cost Analysis
LLNL = Lawrence Livermore National Laboratory
NEPA = National Environmental Policy Act
PCBs = Polychlorinated biphenyls
RCRA = Resource Conservation and Recovery Act
ROD = Record of Decision
TSCA = Toxic Substances Control Act

Appendix A

Building 850 Soil Analytical Data

Appendix A

Building 850 Soil Analytical Data

List of Tables

Table A-1. Surface soil analyses for PCB compounds (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

PCBs in Surface Soil, Site 300 in the Building 850 Area

Table A-1. Surface soil analyses for PCB compounds (mg/kg) in samples collected from the Building 850 area between Januaray 1, 1988 and June 30, 2007.

Location	Laboratory	Depth (ft)	Sampled	PCB 1016 mg/kg	PCB 1221 mg/kg	PCB 1232 mg/kg	PCB 1242 mg/kg	PCB 1248 mg/kg	PCB 1254 mg/kg	PCB 1260 mg/kg	PCB 1268 mg/kg	Total PCBs mg/kg
3SS-850-100	CS	0	26-Jul-94	<0.02 U	<0.02 U	<0.02 U	<0.02 U	<0.02 U	**0.1**	<0.02 U		
3SS-850-101	CS	0	26-Jul-94	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	**4 D**	<0.2 DU		
3SS-850-102	CS	0	26-Jul-94	<0.02 U	<0.02 U	<0.02 U	<0.02 U	<0.02 U	**0.28**	<0.02 U		
3SS-850-103	CS	0	26-Jul-94	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	**3 D**	<0.2 DU		
3SS-850-104	CS	0	26-Jul-94	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	**4.8 D**	<0.2 DU		
3SS-850-104	CS	0	26-Jul-94	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	**2.8 D**	<0.2 DU		
3SS-850-105	CS	0	26-Jul-94	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	**2.8 D**	<0.2 DU		
3SS-850-106	CS	0	26-Jul-94	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	<0.2 DU	**5.3 D**	<0.2 DU		
3SS-850-107	CS	0	26-Jul-94	<1 DU	<1 DU	<1 DU	<1 DU	<1 DU	**17 D**	<1 DU		
3SS-850-107	EF	0.5	20-Oct-94									**41**
3SS-850-107	EF	0.5	20-Oct-94									**40**
3SS-850-107	GE	0	31-Oct-05	<0.355 DU	<0.355 DU	<0.355 DU	<0.355 DU	<0.355 DU	**1.95 D**	<0.355 DU		
3SS-850-113	EF	0	20-Oct-94									**1.6**
3SS-850-114	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-114	EF	0	2-Nov-94									<0.5 U
3SS-850-115	EF	0	19-Oct-94									**1.75**
3SS-850-115	EF	0	19-Oct-94									**0.5**
3SS-850-115	EF	0	19-Oct-94									**2.5**
3SS-850-115	EF	0	19-Oct-94									<0.5 U
3SS-850-117	EF	0	19-Oct-94									<0.5 U
3SS-850-117	EF	0	19-Oct-94									<0.5 U
3SS-850-118	EF	0	19-Oct-94									<0.5 U
3SS-850-118	EF	0	19-Oct-94									<0.5 U
3SS-850-119	EF	0	19-Oct-94									<0.5 U
3SS-850-119	EF	0	19-Oct-94									<0.5 U
3SS-850-121	EF	0	19-Oct-94									<0.5 U
3SS-850-121	EF	0	19-Oct-94									<0.5 U
3SS-850-122	EF	0	19-Oct-94									**0.8**
3SS-850-122	EF	0	19-Oct-94									<0.5 U
3SS-850-122	EF	0	19-Oct-94									**3.25**
3SS-850-122	EF	0	19-Oct-94									<0.5 U
3SS-850-123	EF	0.5	2-Dec-94									<0.5 U
3SS-850-126	EF	0.5	2-Dec-94									<0.5 U
3SS-850-129	EF	0	20-Oct-94									**23.75**
3SS-850-129	EF	0.5	20-Oct-94									**1.15**
3SS-850-129	EF	0.5	20-Oct-94									**0.75**
3SS-850-129	CS	0	2-Dec-94	<2 DHU	<2 DHU	<2 DHU	<2 DHU	<2 DHU	**5.9 DH**	<2 DHU		
3SS-850-130	EF	0	2-Nov-94									**0.7**
3SS-850-131	CS	0	2-Dec-94	<0.02 HU	<0.02 HU	<0.02 HU	<0.02 HU	<0.02 HU	**0.09 H**	<0.02 HU		
3SS-850-132	EF	0	19-Oct-94									<0.5 U
3SS-850-132	EF	0	19-Oct-94									**0.55**
3SS-850-133	EF	0	20-Oct-94									**0.5**
3SS-850-134	CS	0	20-Oct-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-134	EF	0	20-Oct-94									**1.6**
3SS-850-135	CS	0	20-Oct-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-135	EF	0	20-Oct-94									<0.5 U
3SS-850-136	EF	0	20-Oct-94									**2.8**

Table A-1. Surface soil analyses for PCB compounds (mg/kg) in samples collected from the Building 850 area between Januaray 1, 1988 and June 30, 2007.

Location	Laboratory	Depth (ft)	Sampled	PCB 1016 mg/kg	PCB 1221 mg/kg	PCB 1232 mg/kg	PCB 1242 mg/kg	PCB 1248 mg/kg	PCB 1254 mg/kg	PCB 1260 mg/kg	PCB 1268 mg/kg	Total PCBs mg/kg
3SS-850-136	CS	0	2-Dec-94	<2 DHU	<2 DHU	<2 DHU	<2 DHU	<2 DHU	**20 DH**	<2 DHU		
3SS-850-137	EF	0	20-Oct-94									**4**
3SS-850-138	EF	0	20-Oct-94									**3.25**
3SS-850-139	EF	0	20-Oct-94									**29**
3SS-850-139	CS	0	5-Dec-94	<2 DU	<2 DU	<2 DU	<2 DU	<2 DU	**13 D**	<2 DU		
3SS-850-140	EF	0	21-Oct-94									**7.85**
3SS-850-140	EF	0.5	30-Jan-95									**6.75**
3SS-850-141	EF	0	21-Oct-94									**1.3**
3SS-850-142	EF	0	21-Oct-94									**37.75**
3SS-850-142	EF	0.5	21-Oct-94									**6.6**
3SS-850-142	CS	0	2-Dec-94	<20 DHU	<20 DHU	<20 DHU	<20 DHU	<20 DHU	**180 DH**	<20 DHU		
3SS-850-142	CS	0.5	2-Dec-94	<20 DHU	<20 DHU	<20 DHU	<20 DHU	<20 DHU	**120 DH**	<20 DHU		
3SS-850-143	CS	0	2-Nov-94	<2 DU	<2 DU	<2 DU	<2 DU	<2 DU	**12 D**	<2 DU		
3SS-850-144	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	**1.4**	<1 U		
3SS-850-145	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	**6.8**	<1 U		
3SS-850-146	EF	0	21-Oct-94									<0.5 U
3SS-850-146	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-146	EF	0	2-Nov-94									<0.5 U
3SS-850-147	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-147	EF	0	2-Nov-94									<0.5 U
3SS-850-147	GE	0	31-Oct-05	<0.363 DU	<0.363 DU	<0.363 DU	<0.363 DU	<0.363 DU	**5.34 D**	<0.363 DU		
3SS-850-148	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-148	EF	0	2-Nov-94									<0.5 U
3SS-850-149	EF	0	2-Nov-94									<0.5 U
3SS-850-150	EF	0	2-Nov-94									**0.7**
3SS-850-151	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-151	EF	0	2-Nov-94									<0.5 U
3SS-850-152	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-153	CS	0	2-Nov-94	<2 DU	<2 DU	<2 DU	<2 DU	<2 DU	**13 D**	<2 DU		
3SS-850-153	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	**11**	<1 U		
3SS-850-153	EF	0	2-Nov-94									**37.75**
3SS-850-154	CS	0	2-Nov-94	<2 DU	<2 DU	<2 DU	<2 DU	<2 DU	<2 DU	<2 DU		
3SS-850-154	CS	0	2-Nov-94	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U	<1 U		
3SS-850-154	EF	0	2-Nov-94									<0.5 U
3SS-850-155	CS	0	2-Dec-94	<0.02 HU	<0.02 HU	<0.02 HU	<0.02 HU	<0.02 HU	**0.33 H**	<0.02 HU		
3SS-850-155	CS	0	2-Dec-94	<0.02 HU	<0.02 HU	<0.02 HU	<0.02 HU	<0.02 HU	**0.38 H**	<0.02 HU		
3SS-850-204	SE	0	24-Oct-03	<0.02 ILU	<0.08 ILU	<0.02 ILU	<0.02 LIU	<0.02 ILU	**0.057 JIL**	<0.02 IUL	<0.02 ILU	
3SS-850-205	SE	0	24-Oct-03	<1 ILUD	<4 ILUD	<1 ILUD	<1 ILUD	<1 ILUD	**3.7 JILD**	<1 IUDL	<1 ILUD	
3SS-850-206	SE	0	24-Oct-03	<20 ILUD	<80 ILUD	<20 ILUD	<20 ILUD	<20 ILUD	**130 JILD**	<20 IUDL	<20 ILUD	
3SS-850-206	GE	0	31-Oct-05	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	**9.2 D**	<0.361 DU		
3SS-850-207	SE	0	24-Oct-03	<0.2 ILUD	<0.8 ILUD	<0.2 ILUD	<0.2 ILUD	<0.2 ILUD	**1.5 JILD**	<0.2 IUDL	<0.2 ILUD	
3SS-850-208	SE	0	24-Oct-03	<0.8 ILUD	<3.2 ILUD	<0.8 ILUD	<0.8 ILUD	<0.8 ILUD	**3.9 JILD**	<0.8 ILUD	<0.8 ILUD	
3SS-850-209	SE	0	24-Oct-03	<0.1 ILUD	<0.4 ILUD	<0.1 ILUD	<0.1 ILUD	<0.1 ILUD	**0.62 JILD**	<0.1 ILUD	<0.1 ILUD	
3SS-850-210	SE	0	24-Oct-03	<1 ILUD	<4 ILUD	<1 ILUD	<1 ILUD	<1 ILUD	**5.4 JILD**	<1 IUDL	<1 ILUD	
3SS-850-211	SE	0	24-Oct-03	<4 ILUD	<16 ILUD	<4 ILUD	<4 ILUD	<4 ILUD	**18 JILD**	<4 IUDL	<4 ILUD	
3SS-850-211	GE	0	31-Oct-05	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	**4.59 D**	<0.361 DU		
3SS-850-211	GE	0	31-Oct-05	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	**5 D**	<0.361 DU		

Table A-1. Surface soil analyses for PCB compounds (mg/kg) in samples collected from the Building 850 area between Januaray 1, 1988 and June 30, 2007.

Location	Laboratory	Depth (ft)	Sampled	PCB 1016 mg/kg	PCB 1221 mg/kg	PCB 1232 mg/kg	PCB 1242 mg/kg	PCB 1248 mg/kg	PCB 1254 mg/kg	PCB 1260 mg/kg	PCB 1268 mg/kg	Total PCBs mg/kg
3SS-850-212	SE	0	24-Oct-03	<20 ILUD	<80 ILUD	<20 ILUD	<20 ILUD	<20 ILUD	**110 JILD**	<20 IUDL	<20 ILUD	
3SS-850-212	GE	0	31-Oct-05	<3.39 DU	<3.39 DU	<3.39 DU	<3.39 DU	<3.39 DU	**65 D**	<3.39 DU		
3SS-850-213	SE	0	24-Oct-03	<0.02 ILU	<0.08 ILU	<0.02 ILU	<0.02 ILU	<0.02 ILU	**0.12 JIL**	<0.02 IUL	<0.02 ILU	
3SS-850-214	CN	0	27-Oct-03	<0.004 DU	<0.004 DU	<0.004 DU	<0.004 DU	<0.004 DU	**0.907 D**	**0.243 D**		
3SS-850-215	CN	0	27-Oct-03	<0.8 DIJU	<0.8 DIJU	<0.8 DIJU	<0.8 DIJU	<0.8 DIJU	**7 DIJ**	**0.7 DIJ**		
3SS-850-216	CN	0	27-Oct-03	<4 DIJU	<4 DIJU	<4 DIJU	<4 DIJU	<4 DIJU	**68 DIJ**	**4 DIJ**		
3SS-850-216	GE	0	31-Oct-05	<3.41 DU	<3.41 DU	<3.41 DU	<3.41 DU	<3.41 DU	**16.1 D**	<3.41 DU		
3SS-850-217	SE	0	24-Oct-03	<0.2 ILUD	<0.8 ILUD	<0.2 ILUD	<0.2 ILUD	<0.2 ILUD	**3 JILD**	<0.2 IUDL	<0.2 ILUD	
3SS-850-218	SE	0	24-Oct-03	<0.1 ILUD	<0.4 ILUD	<0.1 ILUD	<0.1 ILUD	<0.1 ILUD	**0.74 JILD**	<0.1 IUDL	<0.1 ILUD	
3SS-850-219	SE	0	24-Oct-03	<0.2 ILUD	<0.8 ILUD	<0.2 ILUD	<0.2 ILUD	<0.2 ILUD	**4 JILD**	<0.2 IUDL	<0.2 ILUD	
3SS-850-220	SE	0	24-Oct-03	<1 ILUD	<4 ILUD	<1 ILUD	<1 ILUD	<1 ILUD	**11 JILD**	<1 IUDL	<1 ILUD	
3SS-850-221	SE	0	24-Oct-03	<0.2 ILUD	<0.8 ILUD	<0.2 ILUD	<0.2 ILUD	<0.2 ILUD	**1.2 JILD**	<0.2 IUDL	<0.2 ILUD	
3SS-850-222	CN	0	27-Oct-03	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	**0.362 D**	**0.035 D**		
3SS-850-223	CN	0	27-Oct-03	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	**2 DIJ**	**0.123 DIJ**		
3SS-850-224	CN	0	27-Oct-03	<0.04 DU	<0.04 DU	<0.04 DU	<0.04 DU	<0.04 DU	**0.205 D**	**0.0528 D**		
3SS-850-225	CN	0	27-Oct-03	<0.008 DU	<0.008 DU	<0.008 DU	<0.008 DU	<0.008 DU	**0.0326 D**	<0.008 DU		
3SS-850-226	CN	0	27-Oct-03	<0.008 DU	<0.008 DU	<0.008 DU	<0.008 DU	<0.008 DU	**0.0398 D**	<0.008 DU		
3SS-850-227	CN	0	27-Oct-03	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	**0.46 D**	**0.1 D**		
3SS-850-227	GE	0	31-Oct-05	<3.4 DU	<3.4 DU	<3.4 DU	<3.4 DU	<3.4 DU	**45.6 D**	<3.4 DU		
3SS-850-228	CN	0	27-Oct-03	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	**2 DIJ**	**0.483 DIJ**		
3SS-850-229	CN	0	27-Oct-03	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	<0.2 DIJU	**2 DIJ**	**0.398 DIJ**		
3SS-850-230	CN	0	27-Oct-03	<0.4 DIJU	<0.4 DIJU	<0.4 DIJU	<0.4 DIJU	<0.4 DIJU	**3 DIJ**	**0.671 DIJ**		
3SS-850-230	GE	0	31-Oct-05	<3.42 DU	<3.42 DU	<3.42 DU	<3.42 DU	<3.42 DU	**47.5 D**	<3.42 DU		
3SS-850-231	CN	0	27-Oct-03	<0.04 DU	<0.04 DU	<0.04 DU	<0.04 DU	<0.04 DU	**0.45 D**	**0.0452 D**		
3SS-850-232	SE	0	24-Oct-03	<0.2 ILUD	<0.8 ILUD	<0.2 ILUD	<0.2 ILUD	<0.2 ILUD	**6.7 JILD**	<0.2 ILUDL	<0.2 ILUD	
3SS-850-233	CN	0	27-Oct-03	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	**0.99 D**	**0.154 D**		
3SS-850-234	CN	0	27-Oct-03	<0.04 DU	<0.04 DU	<0.04 DU	<0.04 DU	<0.04 DU	**0.498 D**	**0.0601 D**		

Notes:

ft = Feet
mg/kg = Milligrams per kilogram
D = Analysis performed at a secondary dilution or concentration (i.e., vapor samples)
H = Sample analyzed outside of holding time, sample results should be evaluated
J = Analyte was postively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
L = Spike accuracy not within control limits
I = Surrogate recoveries outside of QC limits.
CN = Caltest Analytical Laboratory
CS = California Laboratory Services
EF = ERD Field Sampling
GE = GEL Laboratories, LLC
SE = Sequoia Analytical Laboratory

Table A-2. Subsurface soil and rock analyses for PCB compounds (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

PCBs in Soil, Site 300 in the Building 850 Area

Table A-2. Subsurface soil analyses for PCB compounds (mg/kg) in samples collected from the Building 850 area between Januaray 1, 1988 and June 30, 2007.

Location	Laboratory	Depth (ft)	Sampled	PCB 1016 mg/kg	PCB 1221 mg/kg	PCB 1232 mg/kg	PCB 1242 mg/kg	PCB 1248 mg/kg	PCB 1254 mg/kg	PCB 1260 mg/kg	PCB 1268 mg/kg	Total PCBs mg/kg
3SS-850-136	EF	1	30-Jan-95									**25.5**
3SS-850-136	EF	2	30-Jan-95									<.5 U
3SS-850-136	EF	2	30-Jan-95									**5.8**
3SS-850-136	EF	3	30-Jan-95									<.5 U
3SS-850-136	EF	4	30-Jan-95									<.5 U
3SS-850-139	EF	0.8	2-Dec-94									**23.75**
3SS-850-139	EF	1.3	2-Dec-94									**0.95**
3SS-850-139	EF	1.3	2-Dec-94									**2.5**
3SS-850-139	EF	1.5	30-Jan-95									**8.4**
3SS-850-139	EF	1.8	30-Jan-95									<.5 U
3SS-850-140	EF	0.8	30-Jan-95									**8.4**
3SS-850-142	CS	1	2-Dec-94	<20 DHU	<20 DHU	<20 DHU	<20 DHU	<20 DHU	**96 DH**	<20 DHU		
3SS-850-142	EF	2	30-Jan-95									**32.5**
3SS-850-142	EF	2	30-Jan-95									**>50**
3SS-850-142	EF	2.7	30-Jan-95									**14.45**
3SS-850-209	SE	1	24-Oct-03	<0.1 ILUD	<0.4 ILUD	<0.1 ILUD	<0.1 ILUD	<0.1 ILUD	**.64 JILD**	<0.1 IUDL	<0.1 ILUD	
3SS-850-220	SE	1	24-Oct-03	<4 ILUD	<16 ILUD	<4 ILUD	<4 ILUD	<4 ILUD	**17 JILD**	<4 IUDL	<4 ILUD	
3SS-850-224	CN	1	27-Oct-03	<0.02 DU	<0.02 DU	<0.02 DU	<0.02 DU	<0.02 DU	**.175 D**	**.0348 D**		
3SS-850-229	CN	1	27-Oct-03	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	<0.08 DU	**1 D**	**.203 D**		
B-850-2219	GE	5	25-Apr-06	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	<0.361 DU	**4.4 DB**	**1.96 D**		
B-850-2220	GE	5	25-Apr-06	<3.45 DU	<3.45 DU	<3.45 DU	<3.45 DU	<3.45 DU	**35.8 DB**	**14.6 D**		
B-850-2221	GE	5	25-Apr-06	<0.701 DU	<0.701 DU	<0.701 DU	<0.701 DU	<0.701 DU	**21 DB**	**9.52 D**		
B-850-2222	GE	2.5	25-Apr-06	<0.347 DU	<0.347 DU	<0.347 DU	<0.347 DU	<0.347 DU	**6.91 DB**	**2.87 D**		
B-850-2223	GE	5	25-Apr-06	<0.696 DU	<0.696 DU	<0.696 DU	<0.696 DU	<0.696 DU	**4.53 DB**	**1.95 D**		
B-850-2223	GE	5	25-Apr-06	<0.348 DU	<0.348 DU	<0.348 DU	<0.348 DU	<0.348 DU	**5.86 DB**	**2.89 D**		

Notes:

ft = Feet
mg/kg = Milligrams per kilogram
B = Analyte found in method blank
D = Analysis performed at a secondary dilution or concentration (i.e., vapor samples)
H = Sample analyzed outside of holding time, sample results should be evaluated
J = Analyte was postively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
L = Spike accuracy not within control limits
I = Surrogate recoveries outside of QC limits.
CN = Caltest Analytical Laboratory
CS = California Laboratory Services
EF = ERD Field Sampling
GE = GEL Laboratories, LLC
SE = Sequoia Analytical Laboratory

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

Dioxin and Furan Compounds in Surface Soil, Site 300 in the Building 850 Area

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

Location	**3SS-850-102**
Sampled date	12/16/94
Depth (ft.)	0.0
Validation	V

	Description	Result	Units	Flag
	Moisture by weight	21.000	Percent	
	1,2,3,4,6,7,8-HpCDD	0.000018	mg/kg	
	1,2,3,4,7,8-HxCDD	< 0.0000006	mg/kg	U
	1,2,3,6,7,8-HxCDD	0.0000017	mg/kg	
	1,2,3,7,8,9-HxCDD	0.0000024	mg/kg	
	1,2,3,7,8-PeCDD	< 0.0000003	mg/kg	U
	2,3,7,8-TCDD	< 0.0000006	mg/kg	U
	1,2,3,4,6,7,8-HpCDF	0.0000046	mg/kg	
	1,2,3,4,7,8,9-HpCDF	0.0000006	mg/kg	
	1,2,3,4,7,8-HxCDF	0.0000042	mg/kg	
	1,2,3,6,7,8-HxCDF	0.0000024	mg/kg	
	1,2,3,7,8,9-HxCDF	0.0000026	mg/kg	
	2,3,4,6,7,8-HxCDF	0.000002	mg/kg	
	1,2,3,7,8-PeCDF	0.0000063	mg/kg	
	2,3,4,7,8-PeCDF	0.000014	mg/kg	
	2,3,7,8-TCDF	0.000022	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000031	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	0.0000073	mg/kg	
	Octachlorinated dibenzo-p-dioxin	0.00016	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000014	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	< 0.0000006	mg/kg	U
	Total Dioxins	< 0.0002003	mg/kg	
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.000013	mg/kg	
	Hexachlorinated dibenzo-furans	0.000022	mg/kg	
	Octachlorinated dibenzo-furan	0.000011	mg/kg	
	Pentachlorinated dibenzo-furans	0.000084	mg/kg	
	Tetrachlorinated dibenzo-furans	0.00017	mg/kg	
	Total Furans	0.0003	mg/kg	

Location	**3SS-850-107**
Sampled date	12/16/94
Depth (ft.)	0.0
Validation	V

Description	Result	Units	Flag
Moisture by weight	9.000	Percent	
1,2,3,4,6,7,8-HpCDD	0.000048	mg/kg	
1,2,3,4,7,8-HxCDD	0.0000009	mg/kg	
1,2,3,6,7,8-HxCDD	0.0000025	mg/kg	
1,2,3,7,8,9-HxCDD	0.0000016	mg/kg	
1,2,3,7,8-PeCDD	< 0.0000011	mg/kg	U
2,3,7,8-TCDD	< 0.0000009	mg/kg	U

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

	1,2,3,4,6,7,8-HpCDF	0.000079	mg/kg	
	1,2,3,4,7,8,9-HpCDF	0.000016	mg/kg	
	1,2,3,4,7,8-HxCDF	0.00024	mg/kg	
	1,2,3,6,7,8-HxCDF	0.0002	mg/kg	
	1,2,3,7,8,9-HxCDF	0.000028	mg/kg	
	2,3,4,6,7,8-HxCDF	0.000066	mg/kg	
	1,2,3,7,8-PeCDF	0.00033	mg/kg	
	2,3,4,7,8-PeCDF	0.00078	mg/kg	
	2,3,7,8-TCDF	0.001	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000085	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	0.000015	mg/kg	
	Octachlorinated dibenzo-p-dioxin	0.00041	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000011	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	< 0.0000009	mg/kg	U
	Total Dioxins	< 0.000512	mg/kg	
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.00014	mg/kg	
	Hexachlorinated dibenzo-furans	0.0012	mg/kg	
	Octachlorinated dibenzo-furan	0.00002	mg/kg	
	Pentachlorinated dibenzo-furans	0.0043	mg/kg	
	Tetrachlorinated dibenzo-furans	0.0062	mg/kg	
	Total Furans	0.01186	mg/kg	

Location	**3SS-850-107**
Sampled date	12/16/94
Depth (ft.)	0.5
Validation	V

Description	Result	Units	Flag
Moisture. by weight	9.000	Percent	
1,2,3,4,6,7,8-HpCDD	0.000019	mg/kg	
1,2,3,4,7,8-HxCDD	< 0.0000005	mg/kg	U
1,2,3,6,7,8-HxCDD	0.0000015	mg/kg	
1,2,3,7,8,9-HxCDD	0.0000013	mg/kg	
1,2,3,7,8-PeCDD	< 0.0000008	mg/kg	U
2,3,7,8-TCDD	0.0000007	mg/kg	
1,2,3,4,6,7,8-HpCDF	0.000045	mg/kg	
1,2,3,4,7,8,9-HpCDF	0.000012	mg/kg	
1,2,3,4,7,8-HxCDF	0.00014	mg/kg	
1,2,3,6,7,8-HxCDF	0.00012	mg/kg	
1,2,3,7,8,9-HxCDF	0.000018	mg/kg	
2,3,4,6,7,8-HxCDF	0.000043	mg/kg	
1,2,3,7,8-PeCDF	0.00021	mg/kg	
2,3,4,7,8-PeCDF	0.00045	mg/kg	
2,3,7,8-TCDF	0.00059	mg/kg	
Totals of Dioxin Compounds — Heptachlorinated dibenzo-p-dioxins	0.000034	mg/kg	
Hexachlorinated dibenzo-p-dioxins	0.0000066	mg/kg	
Octachlorinated dibenzo-p-dioxin	0.00017	mg/kg	
Pentachlorinated dibenzo-p-dioxins	< 0.0000012	mg/kg	U

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

	Tetrachlorinated dibenzo-p-dioxins	0.000002	mg/kg
	Total Dioxins	< 0.0002138	mg/kg
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.000083	mg/kg
	Hexachlorinated dibenzo-furans	0.00074	mg/kg
	Octachlorinated dibenzo-furan	0.000081	mg/kg
	Pentachlorinated dibenzo-furans	0.0027	mg/kg
	Tetrachlorinated dibenzo-furans	0.0036	mg/kg
	Total Furans	0.007204	mg/kg

Location	3SS-850-126
Sampled date	12/16/94
Depth (ft.)	0.0
Validation	V

	Description	Result	Units	Flag
	Moisture by weight	25.000	Percent	
	1,2,3,4,6,7,8-HpCDD	0.000011	mg/kg	
	1,2,3,4,7,8-HxCDD	< 0.0000005	mg/kg	U
	1,2,3,6,7,8-HxCDD	< 0.0000011	mg/kg	U
	1,2,3,7,8,9-HxCDD	< 0.0000011	mg/kg	U
	1,2,3,7,8-PeCDD	< 0.0000011	mg/kg	U
	2,3,7,8-TCDD	< 0.0000003	mg/kg	U
	1,2,3,4,6,7,8-HpCDF	0.0000039	mg/kg	
	1,2,3,4,7,8,9-HpCDF	< 0.0000003	mg/kg	U
	1,2,3,4,7,8-HxCDF	0.000001	mg/kg	
	1,2,3,6,7,8-HxCDF	0.0000007	mg/kg	
	1,2,3,7,8,9-HxCDF	0.0000024	mg/kg	
	2,3,4,6,7,8-HxCDF	0.0000007	mg/kg	
	1,2,3,7,8-PeCDF	0.0000015	mg/kg	
	2,3,4,7,8-PeCDF	0.0000027	mg/kg	
	2,3,7,8-TCDF	0.0000041	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000018	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	< 0.0000011	mg/kg	U
	Octachlorinated dibenzo-p-dioxin	0.000088	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000011	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	< 0.0000003	mg/kg	U
	Total Dioxins	< 0.0001085	mg/kg	
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.000016	mg/kg	
	Hexachlorinated dibenzo-furans	0.0000093	mg/kg	
	Octachlorinated dibenzo-furan	0.000019	mg/kg	
	Pentachlorinated dibenzo-furans	0.000015	mg/kg	
	Tetrachlorinated dibenzo-furans	0.000029	mg/kg	
	Total Furans	0.0000883	mg/kg	

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

Location	3SS-850-139			
Sampled date	12/16/94			
Depth (ft.)	0.0			
Validation	V			
	Description	Result	Units	Flag
	Moisture by weight	24.000	Percent	
	1,2,3,4,6,7,8-HpCDD	0.000057	mg/kg	
	1,2,3,4,7,8-HxCDD	< 0.000001	mg/kg	U
	1,2,3,6,7,8-HxCDD	0.0000037	mg/kg	
	1,2,3,7,8,9-HxCDD	0.0000022	mg/kg	
	1,2,3,7,8-PeCDD	< 0.0000012	mg/kg	U
	2,3,7,8-TCDD	< 0.0000008	mg/kg	U
	1,2,3,4,6,7,8-HpCDF	0.000077	mg/kg	
	1,2,3,4,7,8,9-HpCDF	0.000028	mg/kg	
	1,2,3,4,7,8-HxCDF	0.00031	mg/kg	
	1,2,3,6,7,8-HxCDF	0.00017	mg/kg	
	1,2,3,7,8,9-HxCDF	0.000041	mg/kg	
	2,3,4,6,7,8-HxCDF	0.000097	mg/kg	
	1,2,3,7,8-PeCDF	0.00036	mg/kg	
	2,3,4,7,8-PeCDF	0.0012	mg/kg	
	2,3,7,8-TCDF	0.0018	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000097	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	0.000016	mg/kg	
	Octachlorinated dibenzo-p-dioxin	0.00048	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000012	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	< 0.0000008	mg/kg	U
	Total Dioxins	< 0.000595	mg/kg	
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.00017	mg/kg	
	Hexachlorinated dibenzo-furans	0.0012	mg/kg	
	Octachlorinated dibenzo-furan	0.000017	mg/kg	
	Pentachlorinated dibenzo-furans	0.0066	mg/kg	
	Tetrachlorinated dibenzo-furans	0.012	mg/kg	
	Total Furans	0.019987	mg/kg	

Location	3SS-850-140			
Sampled date	12/16/94			
Depth (ft.)	0.0			
Validation	V			
	Description	Result	Units	Flag
	Moisture by weight	6.000	Percent	
	1,2,3,4,6,7,8-HpCDD	0.000023	mg/kg	
	1,2,3,4,7,8-HxCDD	< 0.0000007	mg/kg	U
	1,2,3,6,7,8-HxCDD	0.0000011	mg/kg	
	1,2,3,7,8,9-HxCDD	< 0.0000007	mg/kg	U
	1,2,3,7,8-PeCDD	< 0.0000011	mg/kg	U
	2,3,7,8-TCDD	0.0000014	mg/kg	
	1,2,3,4,6,7,8-HpCDF	0.00015	mg/kg	

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

	1,2,3,4,7,8,9-HpCDF	0.000056	mg/kg	
	1,2,3,4,7,8-HxCDF	0.00054	mg/kg	
	1,2,3,6,7,8-HxCDF	0.00043	mg/kg	
	1,2,3,7,8,9-HxCDF	0.000097	mg/kg	
	2,3,4,6,7,8-HxCDF	0.00015	mg/kg	
	1,2,3,7,8-PeCDF	0.00061	mg/kg	
	2,3,4,7,8-PeCDF	0.0017	mg/kg	
	2,3,7,8-TCDF	0.0019	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000037	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	0.0000059	mg/kg	
	Octachlorinated dibenzo-p-dioxin	0.00016	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000011	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	0.0000043	mg/kg	
	Total Dioxins	< 0.0002083	mg/kg	
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.0003	mg/kg	
	Hexachlorinated dibenzo-furans	0.0027	mg/kg	
	Octachlorinated dibenzo-furan	0.000025	mg/kg	
	Pentachlorinated dibenzo-furans	0.0086	mg/kg	
	Tetrachlorinated dibenzo-furans	0.011	mg/kg	
	Total Furans	0.022625	mg/kg	

Location	**3SS-850-142**
Sampled date	12/16/94
Depth (ft.)	0.0
Validation	V

Description	Result	Units	Flag
Moisture by weight	7.000	Percent	
1,2,3,4,6,7,8-HpCDD	0.000031	mg/kg	
1,2,3,4,7,8-HxCDD	< 0.0000018	mg/kg	U
1,2,3,6,7,8-HxCDD	< 0.0000019	mg/kg	U
1,2,3,7,8,9-HxCDD	< 0.0000018	mg/kg	U
1,2,3,7,8-PeCDD	< 0.0000019	mg/kg	U
2,3,7,8-TCDD	0.0000008	mg/kg	
1,2,3,4,6,7,8-HpCDF	0.00064	mg/kg	
1,2,3,4,7,8,9-HpCDF	0.0002	mg/kg	
1,2,3,4,7,8-HxCDF	0.0023	mg/kg	
1,2,3,6,7,8-HxCDF	0.0021	mg/kg	
1,2,3,7,8,9-HxCDF	0.00025	mg/kg	
2,3,4,6,7,8-HxCDF	0.00075	mg/kg	
1,2,3,7,8-PeCDF	0.0026	mg/kg	
2,3,4,7,8-PeCDF	0.0091	mg/kg	
2,3,7,8-TCDF	0.0096	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000057	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	< 0.0000087	mg/kg	U
	Octachlorinated dibenzo-p-dioxin	0.00024	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000032	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	0.0000038	mg/kg	

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

	Total Dioxins	< 0.0003127	mg/kg
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.0013	mg/kg
	Hexachlorinated dibenzo-furans	0.011	mg/kg
	Octachlorinated dibenzo-furan	0.00011	mg/kg
	Pentachlorinated dibenzo-furans	0.057	mg/kg
	Tetrachlorinated dibenzo-furans	0.048	mg/kg
	Total Furans	0.11741	mg/kg

Location	**3SS-850-142**
Sampled date	12/16/94
Depth (ft.)	0.5
Validation	V

Description	Result	Units	Flag
Moisture by weight	6.000	Percent	
1,2,3,4,6,7,8-HpCDD	0.000052	mg/kg	
1,2,3,4,7,8-HxCDD	< 0.000001	mg/kg	U
1,2,3,6,7,8-HxCDD	0.0000033	mg/kg	
1,2,3,7,8,9-HxCDD	< 0.000001	mg/kg	U
1,2,3,7,8-PeCDD	< 0.0000011	mg/kg	U
2,3,7,8-TCDD	< 0.0000005	mg/kg	U
1,2,3,4,6,7,8-HpCDF	0.00017	mg/kg	
1,2,3,4,7,8,9-HpCDF	0.000046	mg/kg	
1,2,3,4,7,8-HxCDF	0.00055	mg/kg	
1,2,3,6,7,8-HxCDF	0.00051	mg/kg	
1,2,3,7,8,9-HxCDF	0.000063	mg/kg	
2,3,4,6,7,8-HxCDF	0.00018	mg/kg	
1,2,3,7,8-PeCDF	0.00067	mg/kg	
2,3,4,7,8-PeCDF	0.0022	mg/kg	
2,3,7,8-TCDF	0.0026	mg/kg	
Totals of Dioxin Compounds — Heptachlorinated dibenzo-p-dioxins	0.000093	mg/kg	
Hexachlorinated dibenzo-p-dioxins	0.0000033	mg/kg	
Octachlorinated dibenzo-p-dioxin	0.00055	mg/kg	
Pentachlorinated dibenzo-p-dioxins	< 0.0000024	mg/kg	U
Tetrachlorinated dibenzo-p-dioxins	0.0000007	mg/kg	
Total Dioxins	< 0.0006494	mg/kg	
Totals of Furan Compounds — Heptachlorinated dibenzo-furans	0.00034	mg/kg	
Hexachlorinated dibenzo-furans	0.0031	mg/kg	
Octachlorinated dibenzo-furan	0.000026	mg/kg	
Pentachlorinated dibenzo-furans	0.010	mg/kg	
Tetrachlorinated dibenzo-furans	0.015	mg/kg	
Total Furans	0.028466	mg/kg	

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

Location	**3SS-850-147**				
Sampled date	12/16/94				
Depth (ft.)	0.0				
Validation	V				
		Description	Result	Units	Flag
		Moisture by weight	20.000	Percent	
		1,2,3,4,6,7,8-HpCDD	0.0000037	mg/kg	
		1,2,3,4,7,8-HxCDD	< 0.0000005	mg/kg	U
		1,2,3,6,7,8-HxCDD	0.0000009	mg/kg	
		1,2,3,7,8,9-HxCDD	0.0000011	mg/kg	
		1,2,3,7,8-PeCDD	< 0.0000005	mg/kg	U
		2,3,7,8-TCDD	< 0.0000004	mg/kg	U
		1,2,3,4,6,7,8-HpCDF	0.0000017	mg/kg	
		1,2,3,4,7,8,9-HpCDF	< 0.0000005	mg/kg	U
		1,2,3,4,7,8-HxCDF	0.0000021	mg/kg	
		1,2,3,6,7,8-HxCDF	0.0000014	mg/kg	
		1,2,3,7,8,9-HxCDF	0.0000007	mg/kg	
		2,3,4,6,7,8-HxCDF	0.000001	mg/kg	
		1,2,3,7,8-PeCDF	0.0000046	mg/kg	
		2,3,4,7,8-PeCDF	0.0000097	mg/kg	
		2,3,7,8-TCDF	0.000019	mg/kg	
Totals of Dioxin Compounds		Heptachlorinated dibenzo-p-dioxins	0.0000064	mg/kg	
		Hexachlorinated dibenzo-p-dioxins	0.0000036	mg/kg	
		Octachlorinated dibenzo-p-dioxin	0.000022	mg/kg	
		Pentachlorinated dibenzo-p-dioxins	< 0.0000005	mg/kg	U
		Tetrachlorinated dibenzo-p-dioxins	< 0.0000005	mg/kg	U
		Total Dioxins	< 0.000033	mg/kg	
Totals of Furan Compounds		Heptachlorinated dibenzo-furans	0.0000032	mg/kg	
		Hexachlorinated dibenzo-furans	0.000011	mg/kg	
		Octachlorinated dibenzo-furan	0.0000015	mg/kg	
		Pentachlorinated dibenzo-furans	0.000061	mg/kg	
		Tetrachlorinated dibenzo-furans	0.00014	mg/kg	
		Total Furans	0.0002167	mg/kg	

Location	**3SS-850-154**				
Sampled date	12/16/94				
Depth (ft.)	0.0				
Validation	V				
		Description	Result	Units	Flag
		Moisture by weight	20.000	Percent	
		1,2,3,4,6,7,8-HpCDD	0.000021	mg/kg	
		1,2,3,4,7,8-HxCDD	< 0.0000007	mg/kg	U
		1,2,3,6,7,8-HxCDD	0.000002	mg/kg	
		1,2,3,7,8,9-HxCDD	0.0000013	mg/kg	
		1,2,3,7,8-PeCDD	< 0.0000009	mg/kg	U
		2,3,7,8-TCDD	< 0.0000004	mg/kg	U
		1,2,3,4,6,7,8-HpCDF	0.000004	mg/kg	

Table A-3. Surface soil analyses for dioxin and furan compounds (mg/kg) in samples collected from the Building 850 subarea between January 1, 1988 and June 30, 2003.

	1,2,3,4,7,8,9-HpCDF	< 0.0000003	mg/kg	U
	1,2,3,4,7,8-HxCDF	0.0000018	mg/kg	
	1,2,3,6,7,8-HxCDF	< 0.0000003	mg/kg	U
	1,2,3,7,8,9-HxCDF	< 0.0000002	mg/kg	U
	2,3,4,6,7,8-HxCDF	0.0000009	mg/kg	
	1,2,3,7,8-PeCDF	0.0000012	mg/kg	
	2,3,4,7,8-PeCDF	0.0000031	mg/kg	
	2,3,7,8-TCDF	0.0000043	mg/kg	
Totals of Dioxin Compounds	Heptachlorinated dibenzo-p-dioxins	0.000034	mg/kg	
	Hexachlorinated dibenzo-p-dioxins	0.000009	mg/kg	
	Octachlorinated dibenzo-p-dioxin	0.00014	mg/kg	
	Pentachlorinated dibenzo-p-dioxins	< 0.0000009	mg/kg	U
	Tetrachlorinated dibenzo-p-dioxins	< 0.0000004	mg/kg	U
	Total Dioxins	< 0.0001843	mg/kg	
Totals of Furan Compounds	Heptachlorinated dibenzo-furans	0.00001	mg/kg	
	Hexachlorinated dibenzo-furans	0.0000091	mg/kg	
	Octachlorinated dibenzo-furan	0.000007	mg/kg	
	Pentachlorinated dibenzo-furans	0.000018	mg/kg	
	Tetrachlorinated dibenzo-furans	0.000029	mg/kg	
	Total Furans	0.0000731	mg/kg	

Notes:

CLP flags: (follow result)

U Compound was analyzed for, but not detected above detection limit

This page intentionally left blank.

Table A-4. Surface soil analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Uranium Isotopes in Soil, Site 300
November 4, 2003
gemini2

s3uraniumsoL.04nov2003
s3uraniumsoR.04nov2003

Min Sample Date
January 1, 1988
Max Sample Date
June 30, 2003

Table A-4. Surface soil analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in samples

Location Date	Lab	Val. Note		Depth (ft)	Uranium 233+234	Uranium 235+236	Uranium 238	Uranium 235/238 (atom ratio)
FT850-1								
01-dec-1989	GL	a	U	0.0	-	0.008669 P	0.6419 P	-
01-dec-1989	GL	a	U	0.0	-	0.006958 P	0.5072 P	-
01-dec-1989	GL	a	U	0.0	-	0.01046 P	0.6764 P	-
01-dec-1989	GL	a	U	0.0	-	0.01616 P	0.9949 P	-
01-dec-1989	GL	a	U	0.0	-	0.008871 P	0.3767 P	-
01-dec-1989	GL	a	U	0.0	-	0.005944 P	0.1867 P	-
FT850-7								
01-dec-1989	GL	a	U	0.0	-	0.009705 P	0.4483 P	-
01-dec-1989	GL	a	U	0.0	-	0.003749 P	0.1167 P	-
01-dec-1989	GL	a	U	0.0	-	0.004783 P	0.1802 P	-
01-dec-1989	GL	a	U	0.0	-	0.01133 P	0.6452 P	-
01-dec-1989	GL	a	U	0.0	-	0.009086 P	0.5344 P	-
01-dec-1989	GL	a	U	0.0	-	0.0637 P	7.657 P	-
850-18								
20-mar-1990	TM	ap	U	0.4	0.7 +/- 0.1P	<0.1 P	0.8 +/- 0.1P	-
3SS-850-100								
26-jul-1994	IC	ah	V	0.0	-	-	-	0.00227 +/- 5e-05
26-jul-1994	IC	ah	V	0.0	-	-	-	0.00353 +/- 6e-05
3SS-850-101								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00238 +/- 5e-05
3SS-850-102								
26-jul-1994	IC	a	V	0.0	-	-	-	0.0027 +/- 7e-05
3SS-850-103								
26-jul-1994	IC	a	V	0.0	-	-	-	0.0022 +/- 0.00026
3SS-850-104								
26-jul-1994	IC	ah	V	0.0	-	-	-	0.0034 +/- 0.00011
26-jul-1994	IC	aeh	V	0.0	-	-	-	0.00331 +/- 0.00011
3SS-850-105								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00245 +/- 5e-05
3SS-850-106								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00252 +/- 5e-05
3SS-850-107								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00189 +/- 3e-05
3SS-850-108								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00624 +/- 0.0002
3SS-850-109								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00656 +/- 0.00024
3SS-850-110								
26-jul-1994	IC	ah	V	0.0	-	-	-	0.00549 +/- 0.00026
26-jul-1994	IC	ah	V	0.0	-	-	-	0.00546 +/- 0.00024
3SS-850-111								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00371 +/- 0.00012
3SS-850-112								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00382 +/- 9e-05
3SS-850-113								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00234 +/- 7e-05
3SS-850-114								
26-jul-1994	IC	a	V	0.0	-	-	-	0.00277 +/- 0.00023

collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Uranium 233 by mass measurement	Uranium 234 by mass measurement	Uranium 235 by mass measurement	Uranium 236 by mass measurement	Uranium 238 by mass measurement	Location Date
					FT850-1
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
					FT850-7
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
-	-	-	-	-	01-dec-1989
					850-18
-	-	-	-	-	20-mar-1990
					3SS-850-100
-	-	0.044 H	-	3.04	26-jul-1994
-	-	0.021 H	-	0.91	26-jul-1994
					3SS-850-101
-	-	0.033 H	-	2.18	26-jul-1994
					3SS-850-102
-	-	0.027 H	-	1.54	26-jul-1994
					3SS-850-103
-	-	0.046 H	-	3.27	26-jul-1994
					3SS-850-104
-	-	0.014 H	-	0.65	26-jul-1994
-	-	0.018 H	-	0.83	26-jul-1994
					3SS-850-105
-	-	0.041 H	-	2.63	26-jul-1994
					3SS-850-106
-	-	0.029 H	-	1.79	26-jul-1994
					3SS-850-107
-	-	0.301 H	-	24.75	26-jul-1994
					3SS-850-108
-	-	0.016 H	-	0.41	26-jul-1994
					3SS-850-109
-	-	0.015 H	-	0.37	26-jul-1994
					3SS-850-110
-	-	0.013 H	-	0.37	26-jul-1994
-	-	0.013 H	-	0.36	26-jul-1994
					3SS-850-111
-	-	0.027 H	-	1.12	26-jul-1994
					3SS-850-112
-	-	0.013 H	-	0.52	26-jul-1994
					3SS-850-113
-	-	0.039 H	-	2.62	26-jul-1994
					3SS-850-114
-	-	0.012 H	-	0.68	26-jul-1994

Table A-4. Surface soil analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in samples

Location Date	Lab	Val. Note	Depth (ft)	Uranium 233+234	Uranium 235+236	Uranium 238	Uranium 235/238 (atom ratio)
3SS-850-115							
26-jul-1994	IC a	V	0.0	-	-	-	0.00464 +/- 0.00021
26-jul-1994	IT ap	V	0.0	3.42 +/- 0.32	0.35 +/- 0.12	2.65 +/- 0.29	-
3SS-850-116							
26-jul-1994	IC a	V	0.0	-	-	-	0.00516 +/- 0.00032
26-jul-1994	IT ap	V	0.0	2.13 +/- 0.26	0.53 +/- 0.15	1.67 +/- 0.24	-
3SS-850-117							
26-jul-1994	IC a	V	0.0	-	-	-	0.00287 +/- 0.00015
3SS-850-118							
26-jul-1994	IC a	V	0.0	-	-	-	0.00361 +/- 0.0002
3SS-850-119							
26-jul-1994	IC a	V	0.0	-	-	-	0.00436 +/- 0.0002
3SS-850-120							
26-jul-1994	IC ah	V	0.0	-	-	-	0.00293 +/- 8e-05
26-jul-1994	IC ah	V	0.0	-	-	-	0.00271 +/- 0.0001
3SS-850-121							
26-jul-1994	IC a	V	0.0	-	-	-	0.00294 +/- 0.0001
3SS-850-122							
26-jul-1994	IC a	V	0.0	-	-	-	0.00355 +/- 0.0002
3SS-850-123							
26-jul-1994	IC a	V	0.0	-	-	-	0.00639 +/- 0.00038
3SS-850-124							
26-jul-1994	IC a	V	0.0	-	-	-	0.00491 +/- 0.00039
3SS-850-125							
26-jul-1994	IC a	V	0.0	-	-	-	0.00574 +/- 0.00026
3SS-850-126							
26-jul-1994	IC a	V	0.0	-	-	-	0.00288 +/- 0.00025
3SS-850-127							
26-jul-1994	IC a	V	0.0	-	-	-	0.0037 +/- 0.00018
3SS-850-128							
26-jul-1994	IC a	V	0.0	-	-	-	0.00729 +/- 0.00012
3SS-850-129							
26-jul-1994	IC a	V	0.0	-	-	-	0.00322 +/- 0.00027
3SS-850-130A							
26-jul-1994	IC ah	V	0.0	-	-	-	0.00314 +/- 0.00016
26-jul-1994	IC aeh	V	0.0	-	-	-	0.0026 +/- 0.00029
3SS-850-131A							
26-jul-1994	IC a	V	0.0	-	-	-	0.00382 +/- 0.00025

collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Uranium 233 by mass measurement	Uranium 234 by mass measurement	Uranium 235 by mass measurement	Uranium 236 by mass measurement	Uranium 238 by mass measurement	Location Date
					3SS-850-115
-	-	0.013 H	-	0.45	26-jul-1994
-	-	-	-	-	26-jul-1994
					3SS-850-116
-	-	0.014 H	-	0.42	26-jul-1994
-	-	-	-	-	26-jul-1994
					3SS-850-117
-	-	0.023 H	-	1.22	26-jul-1994
					3SS-850-118
-	-	0.01 H	-	0.44	26-jul-1994
					3SS-850-119
-	-	0.01 H	-	0.36	26-jul-1994
					3SS-850-120
-	-	0.017 H	-	0.92	26-jul-1994
-	-	0.024 H	-	1.37	26-jul-1994
					3SS-850-121
-	-	0.02 H	-	1.05	26-jul-1994
					3SS-850-122
-	-	0.011 H	-	0.46	26-jul-1994
					3SS-850-123
-	-	0.015 H	-	0.36	26-jul-1994
					3SS-850-124
-	-	0.012 H	-	0.37	26-jul-1994
					3SS-850-125
-	-	0.012 H	-	0.33	26-jul-1994
					3SS-850-126
-	-	0.019 H	-	1.04	26-jul-1994
					3SS-850-127
-	-	0.018 H	-	0.77	26-jul-1994
					3SS-850-128
-	-	0.013 H	-	0.29	26-jul-1994
					3SS-850-129
-	-	0.02 H	-	0.94	26-jul-1994
					3SS-850-130A
-	-	0.022 H	-	1.07	26-jul-1994
-	-	0.021 H	-	1.24	26-jul-1994
					3SS-850-131A
-	-	0.013 H	-	0.52	26-jul-1994

See following page for notes

Table A-4. Surface soil analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Notes:

- Indicates no analysis performed for this compound

Val. = Validation code

Footnotes:

a ERD data
b ORAD WGMG data
c Analytical results for this sample are suspect
d Sample collected during hydraulic testing
e Blind sample, sent to lab without location identity
f Sample dilution necessary for analysis; detection limits increased
g Interlaboratory collocated sample
h Intralaboratory collocated sample
i Sample collected as part of pilot study
j Note field may contain important information regarding this sample
k Pre-development sample
l Norm month, norm quarter or norm year inconsistent with sample date
m Confirmation sample
n Sample analyzed after standard holding time
o Sample comprised of partial composite
p Alpha spectroscopy analysis of uranium isotopes
q Gamma spectroscopy analysis of uranium isotopes
r Tritium data represents non-detect with activity calc'd for 100 percent error.

Lab Codes:

GL EnvSci Low Level GammaSpec Lab
IC ICP MS Facility
IT International Technology Corp. IS was used for short time.
TM Thermo Analytical Inc.

Validation Codes:

V Validated
N Not validated (default value)
U Undeclared
H Historical comparison only

CLP flags: (follow result)

B Analyte found in method blank
D Analysis performed at a secondary dilution or concentration (i.e., vapor samples)
E The analyte was detected below the LLNL reporting limit, but above the analytical laboratory minimum detection limit.
F Analyte found in field blank, trip blank, or equipment blank
G Quantitated using fuel calibration, but does not match typical fuel fingerprint (fuel maybe gasoline, diesel, motor oil etc.).
H Sample analyzed outside of holding time, sample results should be evaluated
J Analyte was postively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
L Spike accuracy not within control limits
O Duplicate spike or sample precision not within control limits
P Indicates that the absence of a data qualifier flag does not mean that the data does not need qualification, but that the implementation of electronic data qualifier flags was not yet established
R Sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified
S Analytical results for this sample are suspect
T Analyte is tentatively identified compound; result is approximate
U Compound was analyzed for, but not detected above detection limit

Table A-5. Subsurface soil/rock analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Uranium Isotopes in Soil, Site 300
November 4, 2003
gemini2

s3uraniumsoL.04nov2003
s3uraniumsoR.04nov2003

Min Sample Date
January 1, 1988
Max Sample Date
June 30, 2003

Table A-5. Subsurface soil/rock analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in

Location Date	Lab	Val. Note	Depth (ft)	Uranium 233+234	Uranium 235+236	Uranium 238	Uranium 235/238 (atom ratio)
NC7-44							
06-jul-1994	IC a	V	35.5	-	-	-	0.00743 +/- 0.00013
06-jul-1994	IC a	V	35.5	-	-	-	0.0075 +/- 0.00023
NC7-74							
06-jul-1994	IC a	V	35.5	-	-	-	0.00724 +/- 0.00032
06-jul-1994	IC a	V	35.5	-	-	-	0.00731 +/- 0.00026
06-jul-1994	IC a	V	46.0	-	-	-	0.00727 +/- 0.00034
06-jul-1994	IC a	V	46.0	-	-	-	0.00737 +/- 0.0004
06-jul-1994	IC a	V	87.0	-	-	-	0.00721 +/- 9e-05
06-jul-1994	IC a	V	87.0	-	-	-	0.00724 +/- 0.00038
06-jul-1994	IC a	V	101.5	-	-	-	0.00737 +/- 0.00032
06-jul-1994	IC a	V	101.5	-	-	-	0.00752 +/- 0.00048
06-jul-1994	IC a	V	184.5	-	-	-	0.00714 +/- 0.00037
06-jul-1994	IC a	V	184.5	-	-	-	0.00738 +/- 0.00032
06-jul-1994	IC a	V	271.5	-	-	-	0.00726 +/- 0.00017
06-jul-1994	IC a	V	271.5	-	-	-	0.00719 +/- 0.00025
06-jul-1994	IC a	V	322.5	-	-	-	0.00716 +/- 0.00035
06-jul-1994	IC a	V	322.5	-	-	-	0.00715 +/- 0.00035
06-jul-1994	IC a	V	357.5	-	-	-	0.00719 +/- 0.00042
06-jul-1994	IC a	V	357.5	-	-	-	0.00701 +/- 0.0006
06-jul-1994	IC a	V	457.3	-	-	-	0.00741 +/- 0.00036
06-jul-1994	IC a	V	457.3	-	-	-	0.00713 +/- 0.00038
06-jul-1994	IC a	V	496.5	-	-	-	0.00715 +/- 0.00028
06-jul-1994	IC a	V	496.5	-	-	-	0.00738 +/- 0.00036
06-jul-1994	IC a	V	513.5	-	-	-	0.00713 +/- 0.0003
06-jul-1994	IC a	V	513.5	-	-	-	0.00722 +/- 0.00024
850-06							
21-nov-1989	TM ap	U	1.8	3.7 +/- 0.3P	0.5 +/- 0.1P	28.2 +/- 1.7P	-
21-nov-1989	TM ap	U	5.5	0.4 +/- 0.1P	<0.1 P	0.5 +/- 0.1P	-
850-07							
21-nov-1989	TM ap	U	1.8	0.3 +/- 0.1P	<0.1 P	0.4 +/- 0.1P	-
21-nov-1989	TM ap	U	5.8	2.4 +/- 0.2P	0.4 +/- 0.1P	16.9 +/- 0.1P	-
850-09							
21-nov-1989	TM ap	U	1.8	0.4 +/- 0.1P	<0.1 P	0.4 +/- 0.1P	-
21-nov-1989	TM ap	U	5.8	0.3 +/- 0.1P	<0.1 P	0.9 +/- 0.1P	-
850-10							
21-nov-1989	TM ap	U	2.3	0.5 +/- 0.1P	<0.1 P	0.9 +/- 0.1P	-
21-nov-1989	TM ap	U	4.8	0.9 +/- 0.1P	<0.2 P	3.9 +/- 0.3P	-
850-11							
21-nov-1989	TM ap	U	2.0	2.6 +/- 0.2P	0.4 +/- 0.1P	19.4 +/- 1P	-
21-nov-1989	TM ap	U	4.5	0.2 +/- 0.1P	<0.1 P	0.3 +/- 0.1P	-
21-nov-1989	TM ap	U	4.5	0.2 +/- 0.1P	<0.1 P	0.3 +/- 0.1P	-
21-nov-1989	TM ap	U	4.5	0.3 +/- 0.1P	<0.1 P	0.4 +/- 0.1P	-
850-18							
20-mar-1990	TM ap	U	5.5	0.6 +/- 0.1P	<0.1 P	0.6 +/- 0.1P	-
20-mar-1990	TM ap	U	10.5	0.6 +/- 0.1P	<0.1 P	0.5 +/- 0.1P	-
20-mar-1990	TM ap	U	15.2	0.6 +/- 0.2P	<0.1 P	0.9 +/- 0.2P	-
20-mar-1990	TM ap	U	20.2	0.5 +/- 0.1P	<0.1 P	0.7 +/- 0.1P	-
20-mar-1990	TM ap	U	25.3	0.7 +/- 0.1P	<0.1 P	0.8 +/- 0.1P	-

samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Uranium 233 by mass measurement	Uranium 234 by mass measurement	Uranium 235 by mass measurement	Uranium 236 by mass measurement	Uranium 238 by mass measurement	Location Date
					NC7-44
-	-	0.047 H	-	0.98	06-jul-1994
-	-	0.035 H	-	0.73	06-jul-1994
					NC7-74
-	-	0.008 H	-	0.17	06-jul-1994
-	-	0.015 H	-	0.33	06-jul-1994
-	-	0.009 H	-	0.19	06-jul-1994
-	-	0.017 H	-	0.37	06-jul-1994
-	-	0.073 H	-	1.57	06-jul-1994
-	-	0.031 H	-	0.66	06-jul-1994
-	-	0.007 H	-	0.15	06-jul-1994
-	-	0.015 H	-	0.32	06-jul-1994
-	-	0.013 H	-	0.28	06-jul-1994
-	-	0.016 H	-	0.33	06-jul-1994
-	-	0.013 H	-	0.27	06-jul-1994
-	-	0.017 H	-	0.37	06-jul-1994
-	-	0.014 H	-	0.3	06-jul-1994
-	-	0.027 H	-	0.58	06-jul-1994
-	-	0.024 H	-	0.52	06-jul-1994
-	-	0.026 H	-	0.58	06-jul-1994
-	-	0.008 H	-	0.17	06-jul-1994
-	-	0.018 H	-	0.39	06-jul-1994
-	-	0.059 H	-	1.29	06-jul-1994
-	-	0.03 H	-	0.63	06-jul-1994
-	-	0.042 H	-	0.91	06-jul-1994
-	-	0.049 H	-	1.07	06-jul-1994
					850-06
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
					850-07
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
					850-09
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
					850-10
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
					850-11
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
-	-	-	-	-	21-nov-1989
					850-18
-	-	-	-	-	20-mar-1990
-	-	-	-	-	20-mar-1990
-	-	-	-	-	20-mar-1990
-	-	-	-	-	20-mar-1990
-	-	-	-	-	20-mar-1990

See following page for notes

Table A-5. Subsurface soil/rock analyses for uranium isotopes (pCi/g) and $^{235}U/^{238}U$ atom ratios in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Notes:

- Indicates no analysis performed for this compound

Val. = Validation code

Footnotes:

a ERD data
b ORAD WGMG data
c Analytical results for this sample are suspect
d Sample collected during hydraulic testing
e Blind sample, sent to lab without location identity
f Sample dilution necessary for analysis; detection limits increased
g Interlaboratory collocated sample
h Intralaboratory collocated sample
i Sample collected as part of pilot study
j Note field may contain important information regarding this sample
k Pre-development sample
l Norm month, norm quarter or norm year inconsistent with sample date
m Confirmation sample
n Sample analyzed after standard holding time
o Sample comprised of partial composite
p Alpha spectroscopy analysis of uranium isotopes
q Gamma spectroscopy analysis of uranium isotopes
r Tritium data represents non-detect with activity calc'd for 100 percent error.

Lab Codes:

IC ICP MS Facility
TM Thermo Analytical Inc.

Validation Codes:

V Validated
N Not validated (default value)
U Undeclared
H Historical comparison only

CLP flags: (follow result)

B Analyte found in method blank
D Analysis performed at a secondary dilution or concentration (i.e., vapor samples)
E The analyte was detected below the LLNL reporting limit, but above the analytical laboratory minimum detection limit.
F Analyte found in field blank, trip blank, or equipment blank
G Quantitated using fuel calibration, but does not match typical fuel fingerprint (fuel maybe gasoline, diesel, motor oil etc.).
H Sample analyzed outside of holding time, sample results should be evaluated
J Analyte was postively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
L Spike accuracy not within control limits
O Duplicate spike or sample precision not within control limits
P Indicates that the absence of a data qualifier flag does not mean that the data does not need qualification, but that the implementation of electronic data qualifier flags was not yet established
R Sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified
S Analytical results for this sample are suspect
T Analyte is tentatively identified compound; result is approximate
U Compound was analyzed for, but not detected above detection limit

Table A-6. Subsurface soil and rock analyses for tritium (pCi/L_{sm}) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

Tritium in Soil, Site 300 in the Building 850 Area

Table A-6. Subsurface soil and rock analyses for tritium (pCi/L_{sm}) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

Location	Depth (ft)	Sample Date	Tritium (pCi/L)	Tritium (pCi/g)	Moisture by Weight (percent)
850-01	15.5	2-May-88	**5447500±27000P**		14.8P
850-02	5.5	5-May-88	**7300000±36000P**		15.4P
850-02	10.5	5-May-88	**2920000±15000P**		11.9P
850-02	20	6-May-88	**921000±4600P**		18.3P
850-02	25	6-May-88	**669000±3300P**		27.2P
850-02	29.5	6-May-88	**345000±1700P**		18.8P
850-03	11	4-May-88	**37200±390P**		12.9P
850-03	20.5	4-May-88	**254500±1270P**		14.3P
850-03	26	4-May-88	**1805000±9030P**		22.2P
850-03	31	4-May-88	**151300±770P**		22.7P
850-03	34.5	4-May-88	**7400±190P**		18.9P
850-04	9.3	5-May-88	**33600±370P**		20.1P
850-04	20	5-May-88	**2240000±11090P**		20.7P
850-04	25	5-May-88	**1592500±7960P**		14.1P
850-04	30.3	5-May-88	**756500±3780P**		21.8P
850-05	10.3	5-May-88	**5380±160P**		20.6P
850-05	25.3	9-May-88	**29700±1490P**		22.2P
850-05	30.5	9-May-88	**6600±180P**		17.6P
850-05	40.5	9-May-88	**800±110P**		23.9P
850-06	2.3	21-Nov-89	**8100±600P**		17.2P
850-06	6	21-Nov-89	**74200±1400P**		16.4P
850-07	2.3	21-Nov-89	**9100±1200P**		1.5P
850-07	6.3	21-Nov-89	**24200±800P**		14P
850-07	6.8	22-Nov-89	**4100±600P**		16.5P
850-08	1.3	21-Nov-89	**51200±1800P**		4.7P
850-08Z	10.1	21-Mar-90	**45000±1300P**		19.3P
850-08Z	10.1	21-Mar-90	**43500±1200P**		
850-08Z	15.1	21-Mar-90	**7100±600P**		16.2P
850-08Z	20	21-Mar-90	**2300±500P**		19.1P
850-09	2.3	21-Nov-89	**6700±800P**		2.1P
850-09	6.3	21-Nov-89	**6600±600P**		13.8P
850-10	2	21-Nov-89	**4800±600P**		13.6P
850-10	4.3	21-Nov-89	**22600±800P**		13.9P
850-10	6	21-Nov-89	**30600±1000P**		12P
850-11	2.3	21-Nov-89	**12600±800P**		14P
850-11	4	21-Nov-89	**55900±1200P**		21.7P
850-11	5.5	21-Nov-89	**42000±1000P**		17.6P
850-11Z	10.2	21-Mar-90	**204000±5000P**		12.3P
850-11Z	15.2	21-Mar-90	**135000±3000P**		20.2P
850-11Z	20.1	21-Mar-90	**72200±1800P**		17.8P
850-12	3.3	22-Nov-89	**500±500P**		18.6P
850-12	6.3	22-Nov-89	<500P		13.9P
850-12	7	22-Nov-89	<700P		17.4P
850-13	0.8	28-Nov-89	**2500±600P**		14.2P
850-14	1.8	28-Nov-89	**19800±800P**		7.7P
850-14	6.3	28-Nov-89	**74500±3400P**		8.7P
850-14	10	28-Nov-89	**12900±800P**		9.5P
850-14	16.3	28-Nov-89	**8000±600P**		14.4P
850-15	2.3	29-Nov-89	**27400±900P**		4.5P
850-15	6.3	29-Nov-89	**72100±1300P**		16P
850-16	2.3	29-Nov-89	**2600±500P**		16.2P
850-16	6.3	29-Nov-89	<600P		13.7P
850-16	11.3	29-Nov-89	**800±500P**		11.6P
850-16	15.8	29-Nov-89	**700±500P**		12.7P
850-17	2.3	28-Nov-89	**2600±600P**		9.7P
850-17	6.3	28-Nov-89	**14000±6000P**		14P
850-17	11.3	28-Nov-89	**1200±600P**		12.9P
850-17	15.3	28-Nov-89	**1000±600P**		13.8P
850-17	18.3	29-Nov-89	**900±500P**		15P
850-17	19.8	29-Nov-89	**900±500P**		22.6P
850-17	22.8	29-Nov-89	**8300±600P**		19.5P
850-18	5.5	20-Mar-90	**98300±2200P**		14.5P
850-18	10.5	20-Mar-90	**199000±5000P**		19.4P

Table A-6. Subsurface soil and rock analyses for tritium (pCi/L_{sm}) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

Location	Depth (ft)	Sample Date	Tritium (pCi/L)	Tritium (pCi/g)	Moisture by Weight (percent)
850-18	15.2	20-Mar-90	**199000±5000P**		17.1P
850-18	20.2	20-Mar-90	**186000±4000P**		14.4P
850-18	25.3	20-Mar-90	**181000±4000P**		3.1P
850-18	25.3	20-Mar-90	**174000±4000P**		
850-19	5.1	15-Mar-90	**3100±500P**		15.7P
850-19	10.8	15-Mar-90	**195000±5000P**		17.6P
850-19	15	15-Mar-90	**195000±5000P**		18.1P
850-19	20.3	15-Mar-90	**254000±6000P**		22.9P
850-19	25.3	15-Mar-90	**68200±1700P**		16.5P
B-850-2219	5	25-Apr-06		<20±11.5L	7.78
B-850-2220	5	25-Apr-06		<20±10.4L	3.43
B-850-2221	5	25-Apr-06	**377000±226000L**	19.2±10.8	4.96
B-850-2222	2.5	25-Apr-06		<20±10.2L	3.88
B-850-2223	5	25-Apr-06		<20±12.2L	4.24
B-850-2223	5	25-Apr-06		<20±10.3L	4.23
B-865-1803	98	3-Jul-02		<200±0.13	
B-865-1803	106.4	3-Jul-02		<200±0.15	
B-865-1803	114.2	8-Jul-02		<200±0.14	
B-NC2-14S	12	18-Mar-88	**76700±800P**		20P
B-NC2-14S	23.3	18-Mar-88	**40500±590P**		24.1P
B-NC2-15	5	14-Apr-88	**517±220P**		16P
B-NC2-15	14	14-Apr-88	**483±220P**		16.5P
B-NC2-15	26.2	15-Apr-88	**311±220P**		19.1P
B-NC2-15	45.7	15-Apr-88	**366±220P**		5.2P
B-NC2-15	85	18-Apr-88	**23300±490P**		18P
B-NC2-15	100	18-Apr-88	**17200±430P**		19.2P
B-NC2-15	124.3	18-Apr-88	**404±220P**		21P
B-NC2-15	132	18-Apr-88	**441±220P**		20P
B-NC2-18	110.5	1-Feb-90	**620±230P**		20.5P
B-NC2-19	60.5	1-Feb-90	<500P		12.9P
B-NC2-19	74	1-Feb-90	<500P		13.3P
B-NC2-19	79.5	1-Feb-90	<500P		14.5P
B-NC2-19	89.8	15-Nov-89	<600P		13.8P
B-NC2-19	148.5	1-Feb-90	<500P		18P
B-NC2-19	153.8	1-Feb-90	<500P		18.3P
B-NC2-19	162.8	17-Nov-89	<500P		24.1P
B-NC2-20	38.8	31-Jan-90	<500P		21.1P
B-NC2-20	62	31-Jan-90	<800P		19.2P
B-NC2-20	69.8	31-Jan-90	<500P		19.4P
B-NC7-56	18	19-Jan-88	**134000±1400P**		19.6P
B-NC7-58	10.2	29-Jan-88	**4270±250P**		13.4P
B-NC7-58	17	26-Jan-88	**84200±870P**		14.6P
B-NC7-58	20	26-Jan-88	**101000±1000P**		
B-NC7-58	20	26-Jan-88	**98400±1000P**		17.4P
B-NC7-58	20.5	26-Jan-88	**107000±1100P**		20P
B-NC7-58	20.5	29-Jan-88	**107000±1100P**		
B-NC7-58	23.5	26-Jan-88	**107000±1100P**		18.7P
B-NC7-58	24	1-Feb-88	**108000±1100P**		
B-NC7-58	24.7	1-Feb-88	**95500±980P**		20.6P
B-NC7-58	25	1-Feb-88	**108000±1100P**		15P
B-NC7-59	6	29-Jan-88	**15200±380P**		16P
B-NC7-59	11	29-Jan-88	**71800±760P**		19P
B-NC7-59	15.3	29-Jan-88	**123000±1300P**		23.3P
B-NC7-59	21	2-Feb-88	**52500±670P**		21P
B-NC7-59	23	29-Jan-88	**126000±1300P**		
B-NC7-61	14	22-Sep-88	<1000P		20.3P
B-NC7-61	19	12-Sep-88	<1000P		13P
B-NC7-61	29	22-Sep-88	<1000P		13.4P
B-NC7-61	34	22-Sep-88	<1000P		20.2P
B-NC7-61	39	22-Sep-88	<1000P		17.5P
B-NC7-61	44	22-Sep-88	**270000±10000P**		19.8P
B-NC7-61	49	22-Sep-88	**123000±6000P**		14.8P
B-NC7-61	54	22-Sep-88	**6700±1000P**		20.6P

Table A-6. Subsurface soil and rock analyses for tritium (pCi/L_{sm}) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

Location	Depth (ft)	Sample Date	Tritium (pCi/L)	Tritium (pCi/g)	Moisture by Weight (percent)
B-NC7-62	5	19-Oct-88	<1000P		
B-NC7-62	15.3	19-Oct-88	**28000±1000P**		
B-NC7-62	25	11-Oct-88	**135000±7000P**		
B-NC7-62	28.3	11-Oct-88	**63000±3000P**		
B-NC7-69	13.2	31-Jan-90	**3200±400P**		19P
B-NC7-69	18.3	31-Jan-90	**8100±500P**		21.7P
B-NC7-69	26.9	31-Jan-90	**22900±800P**		6.7P
B-NC7-69	31.8	31-Jan-90	<500P		22.2P
B-NC7-69	34.9	31-Jan-90	**800±400P**		21.1P
B-NC7-69	51	31-Jan-90	<500P		29.7P
B-NC7-69	85	31-Jan-90	<500P		20P
B-NC7-69	111	31-Jan-90	<500P		18.3P
B-NC7-69	148.39999	31-Jan-90	<500P		21P
B-NC7-70	4.8	31-Jan-90	**13000±600P**		10.2P
B-NC7-70	14.3	31-Jan-90	**612000±12000P**		16.6P
B-NC7-70	19.3	31-Jan-90	**2790000±60000P**		10.3P
B-NC7-70	23	31-Jan-90	**2450000±50000P**		22.2P
B-NC7-70	27	31-Jan-90	**1760000±40000P**		23.5P
B-NC7-70	31	21-Nov-89	**218000±3553P**		22.69P
B-NC7-70	34.5	21-Nov-89	**2790±276P**		23.81P
B-NC7-70	41.5	21-Nov-89	**4670±282P**		20.91P
B-NC7-70	45.8	21-Nov-89	<197P		18P
B-NC7-71	9.3	1-Feb-90	**76700±1600P**		17.1P
B-NC7-71	12.3	1-Feb-90	**62100±1300P**		10.2P
B-NC7-71	18.5	1-Feb-90	**12200±600P**		13.6P
B-NC7-71	23	1-Feb-90	**2800±400P**		10.6P
B-NC7-71	33.3	1-Feb-90	<500P		21.5P
B-NC7-71	39.8	1-Feb-90	<500P		20.7P
B-NC7-71	43.5	28-Nov-89	**974±242P**		21.99P
B-NC7-71	63.8	28-Nov-89	<197P		27.05P
B-NC7-71	67.8	28-Nov-89	<197P		14.01P
B-NC7-71	79.8	28-Nov-89	**199±141P**		23.41P
B-NC7-72	5.3	1-Feb-90	<500P		13.4P
B-NC7-72	10.5	1-Feb-90	<600P		10.9P
B-NC7-72	20.5	1-Feb-90	**12400±600P**		13.3P
B-NC7-72	20.5	1-Feb-90	**12400±600P**		
B-NC7-72	20.5	1-Feb-90	**12000±300P**		
B-NC7-72	25.5	1-Feb-90	**101000±2000P**		17.2P
B-NC7-72	28.5	1-Feb-90	**98600±2100P**		29.5P
B-NC7-72	34.5	1-Feb-90	**26100±800P**		23.9P
B-NC7-73	5	1-Feb-90	**800±400P**		12P
B-NC7-73	11.5	1-Feb-90	**16300±700P**		18.7P
B-NC7-73	20.8	1-Feb-90	**82700±1800P**		25P
B-NC7-73	30.5	1-Feb-90	**57100±1200P**		28.2P
B-NC7-73	35.3	5-Dec-89	<280P		24P
B-NC7-73	40.6	1-Feb-90	<500P		21.9P
B-NC7-73	40.6	1-Feb-90	<500P		
B-NC7-73	40.6	1-Feb-90	<500P		
NC2-14C	49.5	1-Apr-88	**3130±230P**		22P
NC2-14C	59	4-Apr-88	**353±170P**		15.4P
NC7-74	454.70001	28-Aug-90	<320P		22P
NC7-74	459.39999	28-Aug-90	<366P		14P
NC7-74	470	29-Aug-90	<320P		18.9P
NC7-74	480.29999	29-Aug-90	<320P		19.6P
NC7-74	493	29-Aug-90	<320P		18.7P
NC7-74	510	10-Sep-90	<320P		18.9P
NC7-74	520	11-Sep-90	<320P		21.4P
W-865-1802	54.3	19-Jun-02		<200±0.083	
W-865-1802	84.3	20-Jun-02		<200±0.094	
W-865-1802	124.4	20-Jun-02		<200±0.094	

Notes:

ft = Feet

pCi/L = Pico Curies per Liter

Table A-6. Subsurface soil and rock analyses for tritium (pCi/L_{sm}) in samples collected from the Building 850 area between January 1, 1988 and June 30, 2007.

Location	Depth (ft)	Sample Date	Tritium (pCi/L)	Tritium (pCi/g)	Moisture by Weight (percent)

pCi/g = Pico Curies per Gram
L = Spike accuracy not within control limits
P = Indicates that the absence of a data qualifier flag does not mean that the data does not need qualification, but that the implementation of electronic data qualifier flags was not yet established

This page intentionally left blank.

Table A-7. Surface soil analyses for TTLC metals (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Total Metals in Surface Soil, Site 300
November 3, 2003
gemini2

s3metttlc.soL.03nov2003
s3metttlc.soR.03nov2003

Min Sample Date
January 1, 1988
Max Sample Date
June 30, 2003

Table A-7. Surface soil analyses for TTLC metals (mg/kg) in samples collected from the Building

Location / Date	Lab	Note	Val.	Depth (ft)	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper
FT850-1												
01-dec-1989	BC	ajl	U	0.0	<1 P	1.5 P	150 P	<0.2 P	5.3 P	22 P	13 P	220 P
01-dec-1989	BC	ajl	U	0.0	<1 P	2 P	97 P	<0.2 P	4.2 P	22 P	8.7 P	440 P
01-dec-1989	BC	ajl	U	0.0	<1 P	2.2 P	110 P	<0.2 P	5.4 P	23 P	9 P	570 P
01-dec-1989	BC	ajl	U	0.0	<1 P	<0.4 P	140 P	<0.2 P	6.8 P	23 P	15 P	64 P
01-dec-1989	BC	ajl	U	0.0	<1 P	2 P	79 P	15 P	4 P	19 P	9.2 P	1000 P
01-dec-1989	BC	ajl	U	0.0	1 P	<0.8 P	150 P	<0.2 P	7.9 P	27 P	16 P	19 P
FT850-7												
01-dec-1989	BC	ajl	U	0.0	<1 P	1.9 P	55 P	<0.2 P	2.3 P	13 P	4.8 P	16 P
01-dec-1989	BC	ajl	U	0.0	<1 P	1.4 P	130 P	<0.2 P	4.6 P	24 P	9.4 P	36 P
01-dec-1989	BC	ajl	U	0.0	<1 P	<0.4 P	200 P	<0.2 P	7 P	26 P	18 P	46 P
01-dec-1989	BC	ajl	U	0.0	<1 P	<0.4 P	180 P	<0.2 P	7.7 P	27 P	17 P	36 P
01-dec-1989	BC	ajl	U	0.0	<1 P	<0.8 P	160 P	<0.2 P	8.6 P	28 P	16 P	38 P
01-dec-1989	BC	ajl	U	0.0	<1 P	1.2 P	220 P	<0.2 P	4 P	22 P	8.5 P	24 P
850-11Z												
21-mar-1990	BC	a	U	0.5	-	-	-	<0.2 P	-	-	-	-
3SS-850-100												
26-jul-1994	CS	a	V	0.0	<1 U	0.55	130	<0.5 U	0.54	20	11	18
3SS-850-101												
26-jul-1994	CS	a	V	0.0	<1 U	0.98	110	<0.5 U	0.2	15	9.1	56
3SS-850-102												
26-jul-1994	CS	a	V	0.0	<1 U	0.86	140	<0.5 U	0.12	22	12	30
3SS-850-103												
26-jul-1994	CS	a	V	0.0	<1 U	1	110	<0.5 U	0.31	23	9.4	35
3SS-850-104												
26-jul-1994	CS	aeh	V	0.0	<1 U	<1 DU	190	0.6	<0.1 U	25	12	34
26-jul-1994	CS	ah	V	0.0	<1 U	<0.5 U	150	0.55	<0.1 U	14	10	26
3SS-850-105												
26-jul-1994	CS	a	V	0.0	<1 U	0.51	170	0.54	0.13	22	12	43
3SS-850-106												
26-jul-1994	CS	a	V	0.0	<1 U	0.98	200	0.59	0.11	22	13	32
3SS-850-107												
26-jul-1994	CS	a	V	0.0	1	1	110	0.59	0.45	20	7	180
3SS-850-108												
26-jul-1994	CS	a	V	0.0	<1 U	1.2	170	0.51	<0.1 U	17	12	24
3SS-850-109												
26-jul-1994	CS	a	V	0.0	<1 U	0.75	170	0.51	<0.1 U	22	12	22
3SS-850-110												
26-jul-1994	CS	a	V	0.0	<1 U	0.67	210	0.57	0.11	26	12	27
3SS-850-111												
26-jul-1994	CS	a	V	0.0	<1 U	0.87	130	<0.5 U	0.12	18	14	33
3SS-850-112												
26-jul-1994	CS	a	V	0.0	<1 U	<0.5 U	90	<0.5 U	<0.1 U	16	9.3	17
3SS-850-113												
26-jul-1994	CS	a	V	0.0	<1 U	0.75	78	0.55	0.11	12	6.6	30
3SS-850-114												
26-jul-1994	CS	a	V	0.0	<1 U	0.7	160	0.51	<0.1 U	19	10	23
3SS-850-115												
26-jul-1994	CS	ag	V	0.0	<1 U	1.2	180	0.6	<0.1 U	13	8.9	19
26-jul-1994	GT	ag	V	0.0	<5 U	1.9	210	0.9	<0.5 U	19	12	26

850 area between January 1, 1988 and October 31, 2003.

Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Location Date
									FT850-1
16 P	<0.01 P	<2 P	20 P	<0.4 P	<0.4 P	<4 P	79 P	75 P	01-dec-1989
17 P	0.02 P	<2 P	19 P	<0.4 P	<0.4 P	<4 P	56 P	59 P	01-dec-1989
43 P	<0.01 P	<2 P	23 P	<0.4 P	<0.4 P	<4 P	56 P	65 P	01-dec-1989
7 P	<0.01 P	<2 P	17 P	<0.4 P	<0.4 P	<4 P	96 P	67 P	01-dec-1989
13 P	<0.01 P	<2 P	21 P	<0.4 P	4.2 P	<4 P	41 P	53 P	01-dec-1989
<6 P	0.03 P	<2 P	13 P	<0.4 P	<0.4 P	<4 P	130 P	63 P	01-dec-1989
									FT850-7
<6 P	<0.01 P	<2 P	14 P	<0.4 P	<0.4 P	<4 P	20 P	32 P	01-dec-1989
6.4 P	0.02 P	<2 P	22 P	<0.4 P	<0.4 P	<4 P	47 P	57 P	01-dec-1989
<6 P	<0.01 P	<2 P	22 P	<0.4 P	<0.4 P	<4 P	110 P	68 P	01-dec-1989
<6 P	<0.01 P	<2 P	21 P	<0.4 P	<0.4 P	<4 P	100 P	68 P	01-dec-1989
<6 P	0.02 P	<2 P	20 P	<0.4 P	<0.4 P	<4 P	96 P	61 P	01-dec-1989
<6 P	<0.01 P	<2 P	21 P	<0.4 P	<0.4 P	<4 P	53 P	47 P	01-dec-1989
									850-11Z
20 P	-	-	-	-	-	-	-	-	21-mar-1990
									3SS-850-100
<10 U	<0.05 U	<5 U	13	<0.5 U	<2.5 U	<1 U	97	48	26-jul-1994
									3SS-850-101
<10 U	<0.05 U	<5 U	17	<0.5 U	<2.5 U	<1 U	67	45	26-jul-1994
									3SS-850-102
<10 U	<0.05 U	<5 U	19	<0.5 U	<2.5 U	<1 U	92	54	26-jul-1994
									3SS-850-103
<10 U	<0.05 U	<5 U	36	<0.5 U	<2.5 U	<1 U	73	64	26-jul-1994
									3SS-850-104
<10 U	<0.05 U	<5 U	20	<0.5 U	<2.5 U	<1 U	100	65	26-jul-1994
<10 U	<0.05 U	<5 U	14	<0.5 U	<2.5 U	<1 U	64	43	26-jul-1994
									3SS-850-105
<10 U	<0.05 U	<5 U	16	<0.5 U	<2.5 U	<1 U	94	59	26-jul-1994
									3SS-850-106
<10 U	<0.05 U	<5 U	18	0.57	<2.5 U	<1 U	80	55	26-jul-1994
									3SS-850-107
21	<0.05 U	<5 U	20	<0.5 U	<2.5 U	<1 U	54	55	26-jul-1994
									3SS-850-108
<10 U	<0.05 U	<5 U	15	<0.5 U	<2.5 U	<1 U	79	47	26-jul-1994
									3SS-850-109
<10 U	<0.05 U	<5 U	15	<0.5 U	<2.5 U	<1 U	95	56	26-jul-1994
									3SS-850-110
<10 U	<0.05 U	<5 U	22	<0.5 U	<2.5 U	<1 U	86	57	26-jul-1994
									3SS-850-111
<10 U	<0.05 U	<5 U	18	<0.5 U	<2.5 U	<1 U	91	53	26-jul-1994
									3SS-850-112
<10 U	<0.05 U	<5 U	11	<0.5 U	<2.5 U	<1 U	110	47	26-jul-1994
									3SS-850-113
<10 U	<0.05 U	<5 U	10	<0.5 U	<2.5 U	<1 U	59	39	26-jul-1994
									3SS-850-114
<10 U	<0.05 U	7.2	15	<0.5 U	<2.5 U	<1 U	65	46	26-jul-1994
									3SS-850-115
<10 U	<0.05 U	<5 U	14	<0.5 U	<2.5 U	<1 U	54	34	26-jul-1994
6	<0.1 U	<1 U	19	<5 U	<1 U	<5 U	79	53	26-jul-1994

Table A-7. Surface soil analyses for TTLC metals (mg/kg) in samples collected from the Building

Location Date	Lab	Note	Val.	Depth (ft)	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper
3SS-850-116												
26-jul-1994	CS	ag	V	0.0	<1 U	1.2	190	0.76	<0.1 U	18	12	21
26-jul-1994	GT	ag	V	0.0	<5 U	1.6	220	1.1	<0.5 U	26	14	26
3SS-850-117												
26-jul-1994	CS	a	V	0.0	<1 U	2.3	180	0.6	<0.1 U	22	12	24
3SS-850-118												
26-jul-1994	CS	a	V	0.0	<1 U	1.4	200	0.76	0.1	24	14	31
3SS-850-119												
26-jul-1994	CS	a	V	0.0	<1 U	1.8	210	0.78	0.1	21	13	27
3SS-850-120												
26-jul-1994	CS	a	V	0.0	1	3.2	190	0.68	0.11	20	12	25
3SS-850-121												
26-jul-1994	CS	a	V	0.0	<1 U	1.7	170	0.53	<0.1 U	22	10	28
3SS-850-122												
26-jul-1994	CS	a	V	0.0	<1 U	2.2	140	<0.5 U	<0.1 U	18	10	35
3SS-850-123												
26-jul-1994	CS	a	V	0.0	<1 U	4.3	160	0.55	<0.1 U	15	12	20
3SS-850-124												
26-jul-1994	CS	a	V	0.0	<1 U	<1 DU	180	0.66	<0.1 U	18	11	25
3SS-850-125												
26-jul-1994	CS	a	V	0.0	<1 U	<1 DU	220	0.71	0.13	28	11	25
3SS-850-126												
26-jul-1994	CS	a	V	0.0	<1 U	1.9	180	0.59	<0.1 U	25	11	26
3SS-850-127												
26-jul-1994	CS	a	V	0.0	<1 U	<1 DU	100	<0.5 U	<0.1 U	11	7.9	15
3SS-850-128												
26-jul-1994	CS	a	V	0.0	<1 U	<1 DU	160	0.61	0.1	12	11	21
3SS-850-129												
26-jul-1994	CS	a	V	0.0	<1 U	2	140	<0.5 U	<0.1 U	25	9.9	19
3SS-850-130A												
26-jul-1994	CS	ah	V	0.0	<1 U	<1 DU	100	<0.5 U	<0.1 U	17	8.8	27
26-jul-1994	CS	aeh	V	0.0	<1 U	<1 DU	140	<0.5 U	0.1	26	10	28
3SS-850-131A												
26-jul-1994	CS	a	V	0.0	<1 U	<1 DU	150	<0.5 U	0.14	19	9.8	30

850 area between January 1, 1988 and October 31, 2003.

Lead	Mercury	Molybdenum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc	Location Date
									3SS-850-116
<10 U	<0.05 U	<5 U	17	<0.5 U	<2.5 U	<1 U	73	43	26-jul-1994
8	<0.1 U	<1 U	26	<5 U	<1 U	<5 U	98	61	26-jul-1994
									3SS-850-117
<10 U	<0.05 U	8.3	15	<0.5 U	<2.5 U	<1 U	100	63	26-jul-1994
									3SS-850-118
<10 U	<0.05 U	<5 U	19	<0.5 U	<2.5 U	<1 U	100	63	26-jul-1994
									3SS-850-119
<10 U	<0.05 U	<5 U	17	<0.5 U	<2.5 U	<1 U	82	56	26-jul-1994
									3SS-850-120
<10 U	<0.05 U	<5 U	16	<0.5 U	<2.5 U	<1 U	77	54	26-jul-1994
									3SS-850-121
<10 U	<0.05 U	9	15	<0.5 U	<2.5 U	<1 U	99	54	26-jul-1994
									3SS-850-122
<10 U	<0.05 U	<5 U	15	<0.5 U	<2.5 U	<1 U	88	55	26-jul-1994
									3SS-850-123
<10 U	<0.05 U	<5 U	15	<0.5 U	<2.5 U	<1 U	92	51	26-jul-1994
									3SS-850-124
<10 U	<0.05 U	<5 U	16	<0.5 U	<2.5 U	<1 U	69	49	26-jul-1994
									3SS-850-125
<10 U	<0.05 U	<5 U	23	<0.5 U	<2.5 U	<1 U	84	58	26-jul-1994
									3SS-850-126
<10 U	<0.05 U	<5 U	20	<0.5 U	<2.5 U	<1 U	92	56	26-jul-1994
									3SS-850-127
<10 U	<0.05 U	<5 U	<10 U	<0.5 U	<2.5 U	<1 U	71	43	26-jul-1994
									3SS-850-128
<10 U	<0.05 U	6.6	12	<0.5 U	<2.5 U	<1 U	59	37	26-jul-1994
									3SS-850-129
<10 U	<0.05 U	<5 U	15	<0.5 U	<2.5 U	<1 U	110	53	26-jul-1994
									3SS-850-130A
<10 U	<0.05 U	6.4	14	<0.5 U	<2.5 U	<1 U	83	48	26-jul-1994
<10 U	<0.05 U	<5 U	20	<0.5 U	<2.5 U	<1 U	110	64	26-jul-1994
									3SS-850-131A
51	<0.05 U	<5 U	18	<0.5 U	<2.5 U	<1 U	77	61	26-jul-1994

See following page for notes

Table A-7. Surface soil analyses for TTLC metals (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Notes:

- Indicates no analysis performed for this compound

Val. = Validation code

Footnotes:

a ERD data
b ORAD WGMG data
c Analytical results for this sample are suspect
d Sample collected during hydraulic testing
e Blind sample, sent to lab without location identity
f Sample dilution necessary for analysis; detection limits increased
g Interlaboratory collocated sample
h Intralaboratory collocated sample
i Sample collected as part of pilot study
j Note field may contain important information regarding this sample
k Pre-development sample
l Norm month, norm quarter or norm year inconsistent with sample date
m Confirmation sample
n Sample analyzed after standard holding time
o Sample comprised of partial composite
p Alpha spectroscopy analysis of uranium isotopes
q Gamma spectroscopy analysis of uranium isotopes
r Tritium data represents non-detect with activity calc'd for 100 percent error.

Lab Codes:

BC Brown & Caldwell Emeryville
CS California Laboratory Services 3249 Fitzgerald Rd. Rancho Cordova, CA 95742
GT Groundwater Tech. Envir. Lab.

Validation Codes:

V Validated
N Not validated (default value)
U Undeclared
H Historical comparison only

CLP flags: (follow result)

B Analyte found in method blank
D Analysis performed at a secondary dilution or concentration (i.e., vapor samples)
E The analyte was detected below the LLNL reporting limit, but above the analytical laboratory minimum detection limit.
F Analyte found in field blank, trip blank, or equipment blank
G Quantitated using fuel calibration, but does not match typical fuel fingerprint (fuel maybe gasoline, diesel, motor oil etc.).
H Sample analyzed outside of holding time, sample results should be evaluated
J Analyte was postively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
L Spike accuracy not within control limits
O Duplicate spike or sample precision not within control limits
P Indicates that the absence of a data qualifier flag does not mean that the data does not need qualification, but that the implementation of electronic data qualifier flags was not yet established
R Sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified
S Analytical results for this sample are suspect
T Analyte is tentatively identified compound; result is approximate
U Compound was analyzed for, but not detected above detection limit

Table A-8. Surface soil analyses for high explosives compounds (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Site 300 HMX Compounds in Soil
November 3, 2003
gemini2

s3hmxso.03nov2003

Min Sample Date
January 1, 1988
Max Sample Date
June 30, 2003

Table A-8. Surface soil analyses for high explosives compounds (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Location Date	Lab	Note	Val.	Depth (ft)	HMX	RDX	TNT
3SS-850-100							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-101							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-102							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-103							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-104							
26-jul-1994	CS	aeh	V	0.0	<0.2 U	<0.15 U	<0.1 U
26-jul-1994	CS	ah	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-105							
26-jul-1994	CS	ag	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-106							
26-jul-1994	CS	ag	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-107							
26-jul-1994	CS	a	V	0.0	2.4	<0.15 U	<0.1 U
3SS-850-108							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-109							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-110							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-111							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-112							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-113							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-114							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-115							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
26-jul-1994	MS	ag	N	0.0	<0.005 U	<0.02 U	<0.02 U
3SS-850-116							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
26-jul-1994	MS	ag	N	0.0	<0.005 U	<0.02 U	<0.02 U
3SS-850-117							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-118							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-119							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-120							
26-jul-1994	CS	a	V	0.0	<0.2 U	<0.15 U	<0.1 U

Table A-8. Surface soil analyses for high explosives compounds (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Location Date	Lab	Val. Note	Depth (ft)	HMX	RDX	TNT
3SS-850-121						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-122						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-123						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-124						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-125						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-126						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-127						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U
3SS-850-128						
26-jul-1994	CS a	V	0.0	<0.2 U	<0.15 U	<0.1 U

See following page for notes

Table A-8. Surface soil analyses for high explosives compounds (mg/kg) in samples collected from the Building 850 area between January 1, 1988 and October 31, 2003.

Notes:

- Indicates no analysis performed for this compound

Val. = Validation code

Footnotes:

a ERD data
b ORAD WGMG data
c Analytical results for this sample are suspect
d Sample collected during hydraulic testing
e Blind sample, sent to lab without location identity
f Sample dilution necessary for analysis; detection limits increased
g Interlaboratory collocated sample
h Intralaboratory collocated sample
i Sample collected as part of pilot study
j Note field may contain important information regarding this sample
k Pre-development sample
l Norm month, norm quarter or norm year inconsistent with sample date
m Confirmation sample
n Sample analyzed after standard holding time
o Sample comprised of partial composite
p Alpha spectroscopy analysis of uranium isotopes
q Gamma spectroscopy analysis of uranium isotopes
r Tritium data represents non-detect with activity calc'd for 100 percent error.

Lab Codes:

CS California Laboratory Services 3249 Fitzgerald Rd. Rancho Cordova, CA 95742
MS C & MS-Gas Chromatography

Validation Codes:

V Validated
N Not validated (default value)
U Undeclared
H Historical comparison only

CLP flags: (follow result)

B Analyte found in method blank
D Analysis performed at a secondary dilution or concentration (i.e., vapor samples)
E The analyte was detected below the LLNL reporting limit, but above the analytical laboratory minimum detection limit.
F Analyte found in field blank, trip blank, or equipment blank
G Quantitated using fuel calibration, but does not match typical fuel fingerprint (fuel maybe gasoline, diesel, motor oil etc.).
H Sample analyzed outside of holding time, sample results should be evaluated
J Analyte was postively identified; the associated numerical value is the approximate concentration of the analyte in the sample.
L Spike accuracy not within control limits
O Duplicate spike or sample precision not within control limits
P Indicates that the absence of a data qualifier flag does not mean that the data does not need qualification, but that the implementation of electronic data qualifier flags was not yet established
R Sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet QC criteria. The presence or absence of the analyte cannot be verified
S Analytical results for this sample are suspect
T Analyte is tentatively identified compound; result is approximate
U Compound was analyzed for, but not detected above detection limit

Appendix B

Total Toxicity Equivalent Concentration Calculations

Appendix B

Total Toxicity Equivalent Concentration Calculations

List of Tables

Table B-1. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-102 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	ND	
Other TCDD	0.00E+00	ND	
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	1.70E-06	1.70E-07
1,2,3,7,8,9-HxCDD	1.00E-01	2.40E-06	2.40E-07
Total HxCDD	0.00E+00	7.30E-06	0.00E+00
Other HxCDD	0.00E+00	7.30E+06	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	1.80E-05	1.80E-07
Total HpCDD	0.00E+00	3.10E-05	0.00E+00
Other HpCDD	0.00E+00	1.30E-05	0.00E+00
OCDD	1.00E-04	1.60E-04	1.60E-08
2,3,7,8-TCDF	1.00E-01	2.20E-05	2.20E-06
Total TCDF	0.00E+00	1.70E-04	0.00E+00
Other TCDF	0.00E+00	1.48E-04	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	6.30E-06	3.15E-07
2,3,4,7,8-PeCDF	5.00E-01	1.40E-05	7.00E-06
Total PeCDF	0.00E+00	8.40E-05	0.00E+00
Other PeCDF	0.00E+00	6.37E-05	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	4.20E-06	4.20E-07
1,2,3,6,7,8-HxCDF	1.00E-01	2.40E-06	2.40E-07
2,3,4,6,7,8-HxCDF	1.00E-01	2.00E-06	2.00E-07
1,2,3,7,8,9-HxCDF	1.00E-01	2.60E-06	2.60E-07
Total HxCDF	0.00E+00	2.20E-05	0.00E+00
Other HxCDF	0.00E+00	1.08E-05	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	4.60E-06	4.60E-08
1,2,3,4,7,8,9-HpCDF	1.00E-02	5.90E-07	5.90E-09
Total HpCDF	0.00E+00	1.30E-05	0.00E+00
Other HpCDF	0.00E+00	7.81E-06	0.00E+00
OCDF	1.00E-04	1.10E-05	1.10E-09
		Total toxicity equivalent concentration	1.13E-05

[a] TEQ_{DEF} - WHO_{98}.

Table B-2. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-107 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	ND	
Other TCDD	0.00E+00	ND	
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	8.60E-07	8.60E-08
1,2,3,6,7,8-HxCDD	1.00E-01	2.50E-06	2.50E-07
1,2,3,7,8,9-HxCDD	1.00E-01	1.60E-06	1.60E-07
Total HxCDD	0.00E+00	1.50E-05	0.00E+00
Other HxCDD	0.00E+00	1.00E-05	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	4.80E-05	4.80E-07
Total HpCDD	0.00E+00	8.50E-05	0.00E+00
Other HpCDD	0.00E+00	3.70E-05	0.00E+00
OCDD	1.00E-04	4.10E-04	4.10E-08
2,3,7,8-TCDF	1.00E-01	1.00E-03	1.00E-04
Total TCDF	0.00E+00	6.20E-03	0.00E+00
Other TCDF	0.00E+00	5.20E-03	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	3.30E-04	1.65E-05
2,3,4,7,8-PeCDF	5.00E-01	7.80E-04	3.90E-04
Total PeCDF	0.00E+00	4.30E-03	0.00E+00
Other PeCDF	0.00E+00	3.19E-03	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	2.40E-04	2.40E-05
1,2,3,6,7,8-HxCDF	1.00E-01	2.00E-04	2.00E-05
2,3,4,6,7,8-HxCDF	1.00E-01	6.60E-05	6.60E-06
1,2,3,7,8,9-HxCDF	1.00E-01	2.80E-05	2.80E-06
Total HxCDF	0.00E+00	1.20E-03	0.00E+00
Other HxCDF	0.00E+00	6.66E-04	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	7.90E-05	7.90E-07
1,2,3,4,7,8,9-HpCDF	1.00E-02	1.60E-05	1.60E-07
Total HpCDF	0.00E+00	1.40E-04	0.00E+00
Other HpCDF	0.00E+00	4.50E-05	0.00E+00
OCDF	1.00E-04	2.00E-05	2.00E-09
		Total toxicity equivalent concentration	5.62E-04

[a] TEQ_{DEF} - WHO_{98}.

Table B-3. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-107 (0.5 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	7.20E-07	7.20E-07
Total TCDD	0.00E+00	2.00E-06	0.00E+00
Other TCDD	0.00E+00	1.28E-06	0.00E+00
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	1.50E-06	1.50E-07
1,2,3,7,8,9-HxCDD	1.00E-01	1.30E-06	1.30E-07
Total HxCDD	0.00E+00	6.60E-06	0.00E+00
Other HxCDD	0.00E+00	3.80E-06	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	1.90E-05	1.90E-07
Total HpCDD	0.00E+00	3.40E-05	0.00E+00
Other HpCDD	0.00E+00	1.50E-05	0.00E+00
OCDD	1.00E-04	1.70E-04	1.70E-08
2,3,7,8-TCDF	1.00E-01	5.90E-04	5.90E-05
Total TCDF	0.00E+00	3.60E-03	0.00E+00
Other TCDF	0.00E+00	3.01E-03	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	2.10E-04	1.05E-05
2,3,4,7,8-PeCDF	5.00E-01	4.50E-04	2.25E-04
Total PeCDF	0.00E+00	2.70E-03	0.00E+00
Other PeCDF	0.00E+00	2.04E-03	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	1.40E-04	1.40E-05
1,2,3,6,7,8-HxCDF	1.00E-01	1.20E-04	1.20E-05
2,3,4,6,7,8-HxCDF	1.00E-01	4.30E-05	4.30E-06
1,2,3,7,8,9-HxCDF	1.00E-01	1.80E-05	1.80E-06
Total HxCDF	0.00E+00	7.40E-04	0.00E+00
Other HxCDF	0.00E+00	4.19E-04	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	4.50E-05	4.50E-07
1,2,3,4,7,8,9-HpCDF	1.00E-02	1.20E-05	1.20E-07
Total HpCDF	0.00E+00	8.30E-05	0.00E+00
Other HpCDF	0.00E+00	2.60E-05	0.00E+00
OCDF	1.00E-04	8.10E-06	8.10E-10
		Total toxicity equivalent concentration	3.28E-04

[a] TEQ_{DEF} - WHO_{98}.

Table B-4. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-107 (0.5 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	ND	
Other TCDD	0.00E+00	ND	
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	ND	
1,2,3,7,8,9-HxCDD	1.00E-01	ND	
Total HxCDD	0.00E+00	ND	
Other HxCDD	0.00E+00	ND	
1,2,3,4,6,7,8-HpCDD	1.00E-02	1.10E-05	1.10E-07
Total HpCDD	0.00E+00	1.80E-05	0.00E+00
Other HpCDD	0.00E+00	7.00E-06	0.00E+00
OCDD	1.00E-04	8.80E-05	8.80E-09
2,3,7,8-TCDF	1.00E-01	4.10E-06	4.10E-07
Total TCDF	0.00E+00	2.90E-05	0.00E+00
Other TCDF	0.00E+00	2.49E-05	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	1.50E-06	7.50E-08
2,3,4,7,8-PeCDF	5.00E-01	2.70E-06	1.35E-06
Total PeCDF	0.00E+00	1.50E-05	0.00E+00
Other PeCDF	0.00E+00	1.08E-05	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	1.00E-06	1.00E-07
1,2,3,6,7,8-HxCDF	1.00E-01	6.90E-07	6.90E-08
2,3,4,6,7,8-HxCDF	1.00E-01	6.80E-07	6.80E-08
1,2,3,7,8,9-HxCDF	1.00E-01	2.40E-06	2.40E-07
Total HxCDF	0.00E+00	9.30E-06	0.00E+00
Other HxCDF	0.00E+00	4.53E-06	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	3.90E-06	3.90E-08
1,2,3,4,7,8,9-HpCDF	1.00E-02	ND	
Total HpCDF	0.00E+00	1.60E-05	0.00E+00
Other HpCDF	0.00E+00	1.21E-05	0.00E+00
OCDF	1.00E-04	1.90E-05	1.90E-09
		Total toxicity equivalent concentration	2.47E-06

[a] TEQ_{DEF} - WHO_{98}.

Table B-5. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-139 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	ND	
Other TCDD	0.00E+00	ND	
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	3.70E-06	3.70E-07
1,2,3,7,8,9-HxCDD	1.00E-01	2.20E-06	2.20E-07
Total HxCDD	0.00E+00	1.60E-05	0.00E+00
Other HxCDD	0.00E+00	1.01E-05	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	5.70E-05	5.70E-07
Total HpCDD	0.00E+00	9.70E-05	0.00E+00
Other HpCDD	0.00E+00	4.00E-05	0.00E+00
OCDD	1.00E-04	4.80E-04	4.80E-08
2,3,7,8-TCDF	1.00E-01	1.80E-03	1.80E-04
Total TCDF	0.00E+00	1.20E-02	0.00E+00
Other TCDF	0.00E+00	1.02E-02	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	3.60E-04	1.80E-05
2,3,4,7,8-PeCDF	5.00E-01	1.20E-03	6.00E-04
Total PeCDF	0.00E+00	6.60E-03	0.00E+00
Other PeCDF	0.00E+00	5.04E-03	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	3.10E-04	3.10E-05
1,2,3,6,7,8-HxCDF	1.00E-01	1.70E-04	1.70E-05
2,3,4,6,7,8-HxCDF	1.00E-01	9.70E-05	9.70E-06
1,2,3,7,8,9-HxCDF	1.00E-01	4.10E-05	4.10E-06
Total HxCDF	0.00E+00	1.20E-03	0.00E+00
Other HxCDF	0.00E+00	5.82E-04	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	7.70E-05	7.70E-07
1,2,3,4,7,8,9-HpCDF	1.00E-02	2.80E-05	2.80E-07
Total HpCDF	0.00E+00	1.70E-04	0.00E+00
Other HpCDF	0.00E+00	6.50E-05	0.00E+00
OCDF	1.00E-04	1.70E-05	1.70E-09
		Total toxicity equivalent concentration	8.62E-04

[a] TEQ_{DEF} - WHO_{98}.

Table B-6. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-140 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	1.40E-06	1.40E-06
Total TCDD	0.00E+00	4.30E-06	0.00E+00
Other TCDD	0.00E+00	2.90E-06	0.00E+00
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	1.10E-06	1.10E-07
1,2,3,7,8,9-HxCDD	1.00E-01	ND	
Total HxCDD	0.00E+00	5.90E-06	0.00E+00
Other HxCDD	0.00E+00	4.80E-06	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	2.30E-05	2.30E-07
Total HpCDD	0.00E+00	3.70E-05	0.00E+00
Other HpCDD	0.00E+00	1.40E-05	0.00E+00
OCDD	1.00E-04	1.60E-04	1.60E-08
2,3,7,8-TCDF	1.00E-01	1.90E-03	1.90E-04
Total TCDF	0.00E+00	1.10E-02	0.00E+00
Other TCDF	0.00E+00	9.10E-03	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	6.10E-04	3.05E-05
2,3,4,7,8-PeCDF	5.00E-01	1.70E-03	8.50E-04
Total PeCDF	0.00E+00	8.60E-03	0.00E+00
Other PeCDF	0.00E+00	6.29E-03	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	5.40E-04	5.40E-05
1,2,3,6,7,8-HxCDF	1.00E-01	4.30E-04	4.30E-05
2,3,4,6,7,8-HxCDF	1.00E-01	1.50E-04	1.50E-05
1,2,3,7,8,9-HxCDF	1.00E-01	9.70E-05	9.70E-06
Total HxCDF	0.00E+00	2.70E-03	0.00E+00
Other HxCDF	0.00E+00	1.48E-03	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	1.50E-04	1.50E-06
1,2,3,4,7,8,9-HpCDF	1.00E-02	5.60E-05	5.60E-07
Total HpCDF	0.00E+00	3.00E-04	0.00E+00
Other HpCDF	0.00E+00	9.40E-05	0.00E+00
OCDF	1.00E-04	2.50E-05	2.50E-09
		Total toxicity equivalent concentration	1.20E-03

[a] TEQ_{DEF} - WHO_{98}.

Table B-7. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-142 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	8.10E-07	8.10E-07
Total TCDD	0.00E+00	3.80E-06	0.00E+00
Other TCDD	0.00E+00	2.99E-06	0.00E+00
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	ND	
1,2,3,7,8,9-HxCDD	1.00E-01	ND	
Total HxCDD	0.00E+00	ND	
Other HxCDD	0.00E+00	ND	
1,2,3,4,6,7,8-HpCDD	1.00E-02	3.10E-05	3.10E-07
Total HpCDD	0.00E+00	5.70E-05	0.00E+00
Other HpCDD	0.00E+00	2.60E-05	0.00E+00
OCDD	1.00E-04	2.40E-04	2.40E-08
2,3,7,8-TCDF	1.00E-01	9.60E-03	9.60E-04
Total TCDF	0.00E+00	4.80E-02	0.00E+00
Other TCDF	0.00E+00	3.84E-02	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	2.60E-03	1.30E-04
2,3,4,7,8-PeCDF	5.00E-01	9.10E-03	4.55E-03
Total PeCDF	0.00E+00	5.70E-02	0.00E+00
Other PeCDF	0.00E+00	4.53E-02	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	2.30E-03	2.30E-04
1,2,3,6,7,8-HxCDF	1.00E-01	2.10E-03	2.10E-04
2,3,4,6,7,8-HxCDF	1.00E-01	7.50E-04	7.50E-05
1,2,3,7,8,9-HxCDF	1.00E-01	2.50E-04	2.50E-05
Total HxCDF	0.00E+00	1.10E-02	0.00E+00
Other HxCDF	0.00E+00	5.60E-03	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	6.40E-04	6.40E-06
1,2,3,4,7,8,9-HpCDF	1.00E-02	2.00E-04	2.00E-06
Total HpCDF	0.00E+00	1.30E-03	0.00E+00
Other HpCDF	0.00E+00	4.60E-04	0.00E+00
OCDF	1.00E-04	1.10E-04	1.10E-08
		Total toxicity equivalent concentration	6.19E-03

[a] TEQ_{DEF} - WHO_{98}.

Table B-8. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-142 (0.5 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	7.40E-07	0.00E+00
Other TCDD	0.00E+00	7.40E-07	0.00E+00
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	3.30E-06	3.30E-07
1,2,3,7,8,9-HxCDD	1.00E-01	ND	
Total HxCDD	0.00E+00	3.30E-06	0.00E+00
Other HxCDD	0.00E+00	ND	
1,2,3,4,6,7,8-HpCDD	1.00E-02	5.20E-05	5.20E-07
Total HpCDD	0.00E+00	9.30E-05	0.00E+00
Other HpCDD	0.00E+00	4.10E-05	0.00E+00
OCDD	1.00E-04	5.50E-04	5.50E-08
2,3,7,8-TCDF	1.00E-01	2.60E-03	2.60E-04
Total TCDF	0.00E+00	1.50E-02	0.00E+00
Other TCDF	0.00E+00	1.24E-02	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	6.70E-04	3.35E-05
2,3,4,7,8-PeCDF	5.00E-01	2.20E-03	1.10E-03
Total PeCDF	0.00E+00	1.00E-02	0.00E+00
Other PeCDF	0.00E+00	7.13E-03	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	5.50E-04	5.50E-05
1,2,3,6,7,8-HxCDF	1.00E-01	5.10E-04	5.10E-05
2,3,4,6,7,8-HxCDF	1.00E-01	1.80E-04	1.80E-05
1,2,3,7,8,9-HxCDF	1.00E-01	6.30E-05	6.30E-06
Total HxCDF	0.00E+00	3.10E-03	0.00E+00
Other HxCDF	0.00E+00	1.80E-03	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	1.70E-04	1.70E-06
1,2,3,4,7,8,9-HpCDF	1.00E-02	4.60E-05	4.60E-07
Total HpCDF	0.00E+00	3.40E-04	0.00E+00
Other HpCDF	0.00E+00	1.24E-04	0.00E+00
OCDF	1.00E-04	2.60E-05	2.60E-09
		Total toxicity equivalent concentration	1.53E-03

[a] TEQ_{DEF} - WHO_{98}.

Table B-9. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-147 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	ND	
Other TCDD	0.00E+00	ND	
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	9.30E-07	9.30E-08
1,2,3,7,8,9-HxCDD	1.00E-01	1.10E-06	1.10E-07
Total HxCDD	0.00E+00	3.60E-06	0.00E+00
Other HxCDD	0.00E+00	1.57E-06	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	3.70E-06	3.70E-08
Total HpCDD	0.00E+00	6.40E-06	0.00E+00
Other HpCDD	0.00E+00	2.70E-06	0.00E+00
OCDD	1.00E-04	2.20E-05	2.20E-09
2,3,7,8-TCDF	1.00E-01	1.90E-05	1.90E-06
Total TCDF	0.00E+00	1.40E-04	0.00E+00
Other TCDF	0.00E+00	1.21E-04	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	4.60E-06	2.30E-07
2,3,4,7,8-PeCDF	5.00E-01	9.70E-06	4.85E-06
Total PeCDF	0.00E+00	6.10E-05	0.00E+00
Other PeCDF	0.00E+00	4.67E-05	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	2.10E-06	2.10E-07
1,2,3,6,7,8-HxCDF	1.00E-01	1.40E-06	1.40E-07
2,3,4,6,7,8-HxCDF	1.00E-01	1.00E-06	1.00E-07
1,2,3,7,8,9-HxCDF	1.00E-01	7.40E-07	7.40E-08
Total HxCDF	0.00E+00	1.10E-05	0.00E+00
Other HxCDF	0.00E+00	5.76E-06	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	1.70E-06	1.70E-08
1,2,3,4,7,8,9-HpCDF	1.00E-02	ND	
Total HpCDF	0.00E+00	3.20E-06	0.00E+00
Other HpCDF	0.00E+00	1.50E-06	0.00E+00
OCDF	1.00E-04	1.50E-06	1.50E-10
		Total toxicity equivalent concentration	7.76E-06

[a] TEQ_{DEF} - WHO_{98}.

Table B-10. Toxicity equivalent concentrations of chlorinated dibenzodioxins and chlorinated dibenzofurans at location 3SS-850-147 (0.0 feet).

Compound	TEF[a]	Measured concentration (mg/kg)	TEC
2,3,7,8-TCDD	1.00E+00	ND	
Total TCDD	0.00E+00	ND	
Other TCDD	0.00E+00	ND	
1,2,3,7,8-PeCDD	1.00E+00	ND	
Total PeCDD	0.00E+00	ND	
Other PeCDD	0.00E+00	ND	
1,2,3,4,7,8-HxCDD	1.00E-01	ND	
1,2,3,6,7,8-HxCDD	1.00E-01	2.00E-06	2.00E-07
1,2,3,7,8,9-HxCDD	1.00E-01	1.30E-06	1.30E-07
Total HxCDD	0.00E+00	9.00E-06	0.00E+00
Other HxCDD	0.00E+00	5.70E-06	0.00E+00
1,2,3,4,6,7,8-HpCDD	1.00E-02	2.10E-05	2.10E-07
Total HpCDD	0.00E+00	3.40E-05	0.00E+00
Other HpCDD	0.00E+00	1.30E-05	0.00E+00
OCDD	1.00E-04	1.40E-04	1.40E-08
2,3,7,8-TCDF	1.00E-01	4.30E-06	4.30E-07
Total TCDF	0.00E+00	2.90E-05	0.00E+00
Other TCDF	0.00E+00	2.47E-05	0.00E+00
1,2,3,7,8-PeCDF	5.00E-02	1.20E-06	6.00E-08
2,3,4,7,8-PeCDF	5.00E-01	3.10E-06	1.55E-06
Total PeCDF	0.00E+00	1.80E-05	0.00E+00
Other PeCDF	0.00E+00	1.37E-05	0.00E+00
1,2,3,4,7,8-HxCDF	1.00E-01	1.80E-06	1.80E-07
1,2,3,6,7,8-HxCDF	1.00E-01	ND	
2,3,4,6,7,8-HxCDF	1.00E-01	9.30E-07	9.30E-08
1,2,3,7,8,9-HxCDF	1.00E-01	ND	
Total HxCDF	0.00E+00	9.10E-06	0.00E+00
Other HxCDF	0.00E+00	6.37E-06	0.00E+00
1,2,3,4,6,7,8-HpCDF	1.00E-02	4.00E-06	4.00E-08
1,2,3,4,7,8,9-HpCDF	1.00E-02	0.00E+00	0.00E+00
Total HpCDF	0.00E+00	1.00E-05	0.00E+00
Other HpCDF	0.00E+00	6.00E-06	0.00E+00
OCDF	1.00E-04	7.00E-06	7.00E-10
		Total toxicity equivalent concentration	2.91E-06

[a] TEQ_{DEF} - WHO_{98}.

Table B-11. Total toxicity equivalent concentrations for surface soil sample locations at the Building 850 Firing Table.

Sample location	Total Toxicity Equivalent Concentration (mg/kg)
3SS-850-102-0.0F	1.13E-05
3SS-850-107-0.0F	5.62E-04[a]
3SS-850-107-0.5F	3.28E-04[a]
3SS-850-126-0.0F	2.47E-06
3SS-850-139-0.0F	8.62E-04[a]
3SS-850-140-0.0F	1.20E-03[a]
3SS-850-142-0.0F	6.19E-03[a]
3SS-850-142-0.5F	1.53E-03[a]
3SS-850-147-0.0F	7.76E-06
3SS-850-154-0.0F	2.91E-06

[a] Value exceeds the PRG of 1.6×10^{-5} mg/kg.

Appendix B Table Acronyms

CDD = Chlorinated dibenzo-p-dioxin.
CDF = Chlorinated dibenzofuran.
HpCDD = Heptachlorinated dibenzo-p-dioxin.
HpCDF = Heptachlorinated dibenzofuran.
HxCDD = Hexachlorinated dibenzo-p-dioxin.
HxCDF = Hexachlorinated dibenzofuran.
mg/kg = Milligram per kilogram.
ND = Non detectable.
OCDD = Octachlorodibenzo-p-dioxin.
OCDF = Octachlorodibenzofuran.
PeCDD = Pentachlorinated dibenzo-p-dioxin.
PeCDF = Pentachlorinated dibenzofuran.
PRG = Preliminary Remediation Goal.
TCDD = Tetrachlorodibenzo-p-dioxin.
TCDF = Tetrachlorodibenzofuran.
TEC = Toxicity Equivalent Concentration.
TEF = Toxicity Equivalency Factor.

Appendix C

Cost Estimates for the Building 850 Soil Removal Action Alternatives

Appendix C

Cost Estimates for the Building 850 Soil Removal Action Alternatives

Cost estimates for the removal action alternatives presented in this Engineering Evaluation/Cost Analysis are presented in Tables C-1 (Alternative 2) and C-2 (Alternative 3). Because No Action would be taken under Alternative 1, there are no cost estimates provided.

The overall volume of contaminated soil to be addressed in Alternatives 2 and 3 is estimated to be approximately 15,422 yd^3 (approximate weight of 23,133 tons). A 20% factor was added to the soil volumes to account for "fluffing" as the soil is excavated (18,432 yd^3).

The costs for handling, transportation, treatment, and disposal of excavated soil and fill component of Alternative 2 are based on estimates provided by LLNL Radioactive and Hazardous Waste Management Division. The costs for soil solidification component of Alternative 3 are based on estimates provided by Conestoga-Rover & Associates, Inc. Soil sample analytical costs are based on existing analytical laboratory contract costs and were adjusted for inflation.

The estimates were prepared in accordance with *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000). Costs are calculated for both capital expenditures and future inspection and maintenance expenses. In accordance with EPA guidance, the cost for the alternatives over time were calculated as present net worth costs to represent the costs in 2007 dollars.

Capital and operation and maintenance costs for each alternative are presented as 2007 present-worth costs using the DOE Office of Management and Budget's 7% discount rate and 3% inflation rate. Total costs for all alternatives were estimated within an accuracy of +50% and -30% in accordance with EPA guidance for developing cost estimates and provided for comparison purposes only.

Appendix C

Tables

Table C-1. Cost estimate for Alternative 2 (Excavation and Offsite Disposal).

Item	Quantity	Unit	Unit Price	Cost
Capital Construction Costs:				
Excavation activities				
Excavation of sandpile	**650**	**hrs**	**$65**	**$42,250**
Excavation of contaminated soils	**2,109**	**hrs**	**$66**	**$139,194**
Disposal activities				
Disposal of <50 mg/kg soils				
Trucking	**1,102**	**truck**	**$2,500**	**$2,755,000**
Materials	**2,204**	**liner**	**$425**	**$936,700**
Disposal fees	**17,628**	**yd^3**	**$142**	**$2,503,176**
Disposal of >50 mg/kg soils				
Trucking	**50**	**truck**	**$2,500**	**$125,000**
Materials	**100**	**liner**	**$425**	**$42,500**
Disposal fees	**804**	**yd^3**	**$533**	**$428,532**
Lift Liner System	**--**	**lump sum**	**--**	**$10,000**
Disposal activity support	**--**	**lump sum**	**--**	**$1,252,570**
	Subtotal: Capital construction costs			**$8,234,922**
Other Construction Related Costs:				
Storm Water Pollution Prevention Plan	**--**	**lump sum**	**--**	**$40,000**
Site restoration	**--**	**lump sum**	**--**	**$95,000**
Verification Sampling and Reporting	**--**	**lump sum**	**--**	**$80,000**
	Subtotal: Other construction related costs			**$215,000**
	Total present worth cost of Alternative 2			**$8,449,922**

Notes:

hrs = Hours
mg/kg = Milligram per kilogram
yd^3 = Cubic yard

Table C-2. Cost estimate for Alternative 3 (Excavation and Onsite Soil Solidification).

Item	Quantity	Unit	Unit Price	Cost
Capital Construction Costs:				
Mobilization/Demobilization	--	lump sum	--	$50,000
Temporary Facilities and Controls	--	lump sum	--	$50,000
Excavation activities				
Excavation of sandpile	650	hr	$65	$42,250
Excavation of contaminated soils	2,109	hr	$66	$139,914
Solidification of Soils				
Solidification	18,432	yd^3	$12	$221,184
Solidification Agent	1,200	ton	$96	$115,200
Consolidation of Solidified Soils				
Consolidation	18,432	yd^3	$12	$221,184
Placement of Cover System				
Surface water runoff diversion	950	l.f.	$9	$8,550
Geogrid layer	6,000	yd^2	$9	$54,000
Cobble layer	2,000	yd^3	$95	$190,000
	Subtotal: Capital construction costs			$1,092,282
Other Construction Related Costs:				
Design/Engineering/Oversight	--	lump sum	--	$400,000
Storm Water Pollution Prevention Plan	--	lump sum	--	$40,000
Slope restoration	--	lump sum	--	$100,000
Erosion control		lump sum		$36,000
Verification Sampling and Reporting	--	lump sum	--	$80,000
	Subtotal: Other construction related costs			$656,000
		Total construction costs		$1,748,282
Annual inspection and maintenance	30	years	$9,800/yr	$294,000
	Total present-worth cost of Alternative 3			$2,042,282

Notes on the following page.

Table C-2. Cost estimate for Alternative 3 (Excavation and Onsite Soil Solidification). (Continued)

Notes:

ft^2 = Square feet
hrs = Hours
l.f. = Linear feet
mg/kg = Milligram per kilogram
yd^3 = Cubic yard
yd^2 = Square yard

1) If an asphalt cover is placed over the biological barrier, an additional $276,000 will be required.

2) If an additional consolidation area is required at the Building 850 Lower Corporation Yard, an additional 15-20% should be added to all costs.

Appendix D

Verification Sampling Plan

Appendix D

Verification Sampling Plan

This verification sampling plan was presented and approved in the Interim Remedial Design Report for Building 850 (Taffet et al., 2004). Because both Alternatives 2 and 3 of this EE/CA include a soil excavation component, this verification sampling plan is applicable to both alternatives.

The PCB and dioxin/furan verification sampling plan was developed using the method described in Chapter 7, Section 7.4 of the EPA guidance, "Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media" (EPA 230/02-89-042, February 1989; for risk-based standards).

The methods given in Section 7.4 base the statistical test on the estimated proportion of the site that remains above the cleanup standard after remediation. The assumption (statistical null hypothesis) is that the site has *not* attained the standard; the decision that the site *has* attained the cleanup standard occurs if and when the statistical test rejects its null hypothesis. Section 7.4 is a simplified test, in which the null hypothesis is rejected if and only if all of the sample results are below the cleanup standard.

The required number of samples, N, depends on the choice of P_0, P_1, alpha (α), and beta (β). Alpha is the "false clean" (false positive) rate, that is, the probability that the statistical procedure will incorrectly decide the site has met the standard. Beta is the "false dirty" (false negative) rate, that is, the probability that the statistical procedure will incorrectly decide the site has not met the standard, if in fact the site has met the standard (that is, the true proportion of the site above the standard is some value P_1, smaller than P_0).

The EPA guidance document (Volume 1) provides for a sample size of fifty-nine (N) for this procedure for the selected values of alpha and P_0, but does not provide associated values for beta and P_1:

Method	P_0	P_1	α	β	N
Simple (7.4)	5%	(na)	5%	(na)	59

Chapter 7 of Volume 1 indicates that these methods may be used with simple random sampling but not with systematic (grid-based) sampling. Therefore, the fifty-nine sample locations were selected using a random number generator to select the X and Y coordinates. Coordinates were selected until all fifty-nine samples fell into the excavation area. The EPA requested 3 additional samples be collected outside the contour line. Three samples were added to the verification plan presented in the Interim Remedial Design Report within the sandpile outline for a total of 64 samples. The sandpile was originally left out of the PCB verification sampling plan because the sandpile was believed to be contaminated only by tritium. However, sampling conducted since the Interim Remedial Design report determined that tritium was no longer an issue, but that PCBs were present in the sandpile. The tritium verification sampling plan is no longer applicable to this project.

The sampling locations are presented on Figure D-1. Samples will be collected using LLNL Environmental Restoration Division's Standard Operating Procedure 1.12, "Surface Soil Sampling" (Goodrich and Depue, 2003). The samples will be analyzed for PCBs at an offsite analytical laboratory by EPA Method 8082 with a reporting limit of 0.005 milligrams per kilogram (mg/kg).

The Interim Site-Wide Record of Decision (DOE, 2001) set the PCB cleanup level to be the industrial soil Preliminary Remediation Goal (PRG). The PCB industrial soil PRG is currently 0.74 mg/kg. Additional excavation and verification sampling will occur if any of the 64 samples contain PCBs above this PRG.

Dioxin and furan verification sampling will begin upon completion of the PCB verification sampling and conclusion by the regulatory agencies that the PCBs have been successfully remediated. The same 64 locations that were sampled for PCBs will also be sampled for dioxins/furans. These dioxin/furan samples will be composited into 5 samples where the average concentration is less than or equal to the current industrial PRG of 1.6×10^{-5} mg/kg (1×10^{-6} risk), while no single sample is contaminated above 5×10^{-6} risk.

The composite samples will be analyzed at an off-site analytical laboratory by EPA Method 8290. Reporting limits will vary depending on the analyte and range from 10 to 50 parts per trillion. To evaluate the results, the toxic equivalent concentration (TEC) for the composite sample will be calculated by multiplying the individual dioxin/furan compound concentration by the associated Toxicity Equivalence Factor (TEF). The TEF is defined as an order of magnitude estimate of the toxicity of the various dioxin and furan compounds relative to the toxicity of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). The sum of the resultant TECs is the total TEC for the sample. Additional excavation and verification sampling will be required if the composite TEC is above the PRG.

References

Goodrich, R., and R. Depue (Eds.) (2003), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs),* Lawrence Livermore National Laboratory, Livermore Calif. (UCRL-MA-109115 Rev. 11).

Taffet, M., V. Dibley, L. Ferry, Daily, Z. Demir, V. Madrid, S. Martins, J. Valett, and S. Bilir (2004), *Interim Remedial Design for the Building 850 Operable Unit at Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-201835).

U.S. EPA (1989a), *Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and Dibenzofurans (CDDs and CDFs) and 1989 Update*, Risk Assessment Forum, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. (PB90-145756).

U.S. EPA (1989b), *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media*, Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, Washington D.C. (EPA 230/02-89-042).

Appendix D

Figure

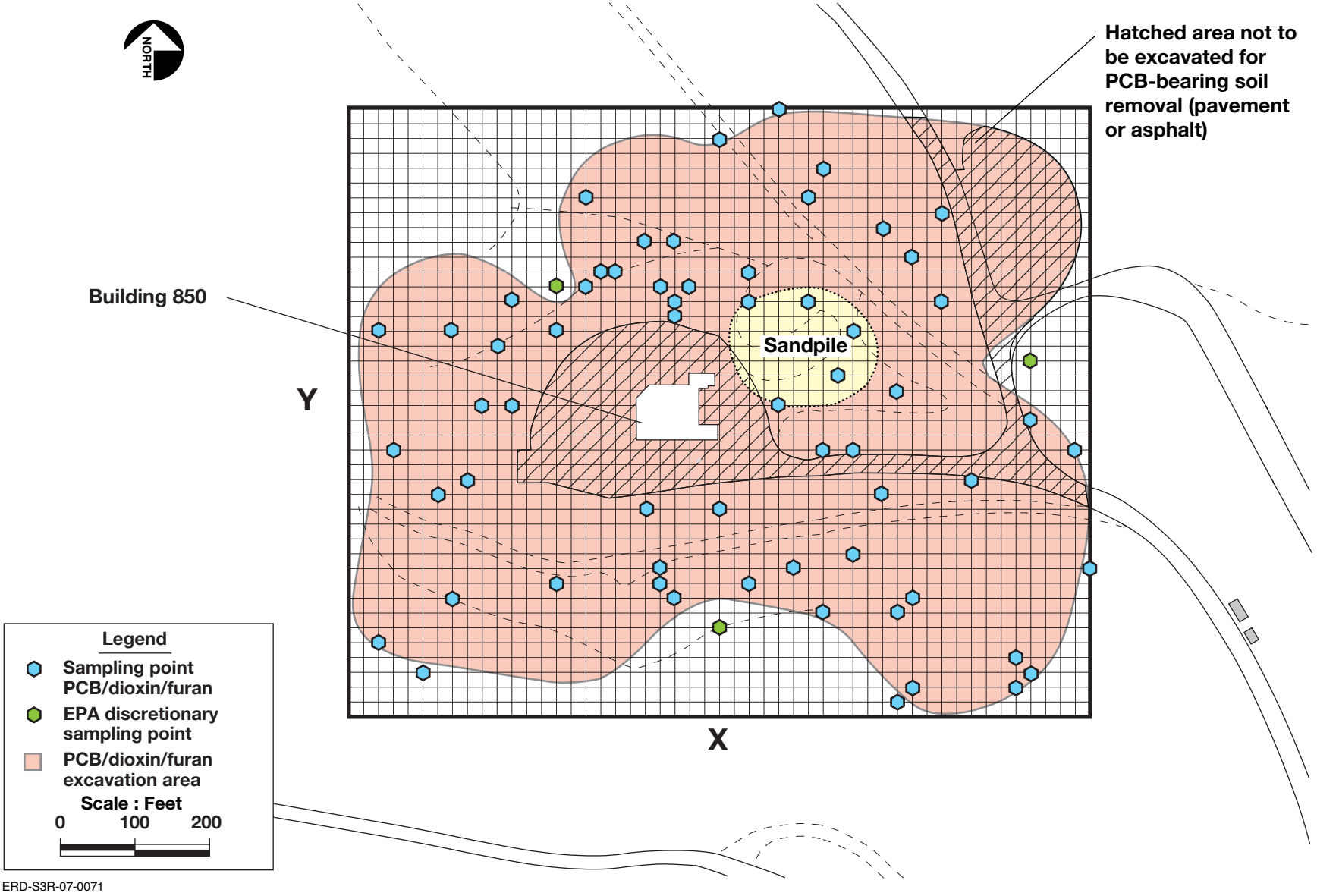


Figure D-1. Polychlorinated biphenyl (PCB), dioxin, and furan excavation verification sample locations in the Building 850 Firing Table area.

Appendix E

Soil Solidification Treatability Study Results

Appendix E

Soil Solidification Treatability Study Results

E.1. Introduction

The project addressed by this Bench Scale Treatability Study is located on the Lawrence Livermore National Laboratory (LLNL) Site 300 property, 17 miles east of Livermore, California. The specific work area is referred to as the Building 850 Firing Table Area in the LLNL remote testing site located off of Corral Hollow Road near Tracy, California. A portion of the hillslopes at Building 850 contains soils with concentrations of polychlorinated biphenyls (PCBs), dioxins, and furans in excess of U.S. EPAs Preliminary Remediation Guidelines (PRGs). These soils occur at a maximum depth of approximately 3 feet below ground surface (bgs). The surface area of the impacted soils is approximately 35,330 square yards and the volume is approximately 15,422 cubic yards.

One of the removal action alternatives being considered (Alternative 3) to address impacted soil is excavation, consolidation and solidification. The soils would be excavated from the hillslopes and other areas in the Building 850, consolidated, and solidified to mitigate onsite worker and ecological exposure to contaminated soil. Solidified soils will have increased strength that is expected to support use of the consolidated area for materials storage and to deter burrowing by animals into the soils. This appendix describes a treatability study that was performed to determine the reagents and their optimum mixture for solidification of the soil.

E-2. Treatment Technology Description

The solidification technology converts contaminated soil into a hard material that cannot be re-suspended or ingested. Once solidified, contaminants in the soil cannot be readily contacted by animals or humans.

One or a combination of solidifying agents such as Portland cement, cement kiln dust, and fly ash, as well as bulking agents such as sawdust or sand if the soil is very wet, are added to the soil. The process of hardening or setting is a chemical reaction called hydration. When water is added to the cement, it forms a slurry or gel that coats the surfaces of the soil and fills the voids. Soon after the soil, water, and the agent(s) are combined, the mixture starts to harden. During hydration, a node forms on the surface of each particle of agent. The node grows and expands until it links up with nodes from other agent particles or adheres to adjacent soil.

Solidification is one of the top five source control treatment technologies used at Superfund sites. It has been used at more than 160 Superfund sites since 1982[1]. Superfund sites where solidification has been used for PCBs include: New Bedford Harbor, New Bedford,

[1] Solidification/stabilization Use at Superfund Sites, U.S. EPA Office of Solid Waste and Emergency Response, EPA-542-R-00-010, September 2000.

Massachusetts; Yellow Water Road, Baldwin, Florida; Peak Oil/Bay Drum, Tampa, Florida; and 90th South Battery Site, West Jordan, Utah.

E-3. Treatability Study Objectives

The primary objectives of the bench-scale treatability study were to gather the data necessary to:

1. Assess the effectiveness of solidification reagents in a representative soil sample from the site to determine whether the increased strength would be sufficient support use of the consolidation area as a materials storage area and to deter burrowing animals.
2. Assess the effectiveness of solidification reagents in a representative soil sample from the site to determine whether a reduction in leaching of PCBs and co-located metals can be obtained.
3. Determine the effective concentration/mass dosage of the selected solidification reagents required to enhance strength to provide long-term integrity and prevent animals from burrowing into the soil.

E-4. Scope of Work and Results

The following section describes the tasks completed during the bench-scale treatability study and the work included under each task.

E-4.1. Task 1: Sample Acquisition And Characterization

Three 5-gallon pails containing soil from the site were received at the Conestoga-Rovers & Associates (CRA) treatability study laboratory in Niagara Falls, New York on March 15, 2007. A thoroughly mixed composite sample was prepared by combining an equal amount of soil from each soil sample in a clean 5-gallon pail.

The composite sample was analyzed by the CRA lab for:

- pH.
- Moisture content.
- Porosity.
- Total organic matter.

The composite sample was sent to Severn Trent Laboratories (STL) for the analysis of:

- PCBs.
- Metals (Beryllium [Be], Cadmium [Cd], and Copper [Cu]).
- Toxicity Characteristic Leaching Procedure (TCLP) PCBs.
- TCLP metals (Be, Cd, and Cu).

The results of the composite sample analyses were compared to historical site data and the composite sample was found to be representative of site conditions and appropriate for use during the treatability study.

The initial characterization of the data showed that the soil was sandy with low moisture content, low organic content, and relatively high porosity. Although Aroclor 1254 was present in the composite sample at 220 milligrams/kilogram (mg/kg), the TCLP test showed that only 13 micrograms per liter (µg/L) of Aroclor 1254 was leached. Beryllium and cadmium were present in the sample at less than 1 mg/kg and copper was present at 132 mg/kg. Leaching of beryllium and cadmium occurred at less than 0.01 milligram per liter (mg/L) and leaching of copper occurred at less than 1 mg/L. The results of the initial characterization are summarized in Table E-1.

E-4.2. Task 2: Initial Solidification Tests

Solidification testing was conducted on the representative composite sample. The reagents screened included Portland cement, cement kiln dust, lime, and fly ash. The tests were prepared by placing soil with the appropriate amount of solidification reagent(s) in a mechanical mixer. Because the soil was fairly dry, water was also added to wet the solidification reagents and facilitate the process. The soil, water, and reagent were mixed for five minutes and then compacted into a plastic mold. The mold was placed in a high humidity chamber for curing. After two weeks the test samples were analyzed for unconfined compressive strength (UCS), and TCLP PCBs and TCLP metals (Be, Cd, and Cu).

The reagent mixtures screened included:

- 5% Portland cement.
- 5% Cement kiln dust, 5% lime.
- 5% Cement kiln dust, 5% fly ash.
- 2.5% Portland cement, 2.5% cement kiln dust.
- 2.5% Cement kiln dust, 2.5% lime.
- 2.5% Cement kiln dust, 2.5% fly ash.
- 2.5% Portland cement, 2.5% lime.
- Untreated control.

The results of the initial testing are summarized in Table E-2 and on Figure E-1. The data show that the UCS for the samples tested were greatly enhanced by the solidification treatment. The values obtained for all samples were greater than 40 pounds per square inch (psi) except for the untreated control sample and the sample solidified with 2.5% cement kiln dust and 2.5% lime. The highest UCS values were obtained from the sample treated with 5% Portland cement, which had a UCS of 126 psi and the sample treated with 2.5% Portland cement and 2.5% cement kiln dust, which had a UCS of 123 psi. The generation of heat during mixing was not detected for any of the reagents tested.

As noted above, the solidification results of the site soils show that the strength of the soils can be greatly enhanced through the addition of Portland cement and cement kiln dust. The

resulting UCS values range from an UCS value that would be typical for very hard, dry clay to values that are consistent with a low end of the strength range for asphalt. The UCS values are significantly less than the UCS of concrete, which would be in the range of the thousands of psi. Although published data on the strength requirements suitable for preventing burrowing animals is not available, the resulting strength obtained from the solidification should be sufficient to deter burrowing animals from digging into the consolidated material.

The strength obtained from the study, if the solidified soil was compacted using standard placement and compaction techniques, would be suitable for the construction of a consolidation area that would be appropriate for carrying loads typically observed in an asphalt paved area. Some enhancements near the slopes of the consolidation area may be required to ensure slope stability. Weathering of the compacted soils would not be a significant concern because the soils would be covered and not exposed to the natural elements and therefore this was not a consideration in evaluating the test results.

The treatment did not appear to significantly reduce leaching through the TCLP testing. Leaching data for the control sample identified 0.021 mg/L Aroclor 1254, 0.19 mg/L copper, 0.0017 mg/L cadmium, and 0.00058 mg/L beryllium. Similar leaching data were obtained for the samples treated with the various reagent mixtures. However, the leaching of Aroclor 1254 and co-located metals in untreated soil from the site was very low, PCBs have low solubility, and ground water has not been impacted by PCBs in Building 850 soil and modeling indicates it will not be impacted.

Test results for the untreated control soil from Building 850 indicate that PCB (Aroclor 1254) concentrations in the leachate (0.021 mg/L) were less than ten times the 0.10 mg/L Universal Treatment Standard (UTS) for PCBs and therefore meets the treatment requirement for CAMU-eligible wastes that the concentrations must be less than 10 times the UTS. Test results for untreated soil also indicate that the TCLP concentrations for beryllium (0.00058 mg/L) and cadmium (0.0017 mg/L) were well below the UTS of 1.22 mg/L and 0.11 mg/L, respectively. The TCLP concentration for copper in the untreated sample was 0.19 mg/L. There is no UTS (TCLP) concentration for copper. TCLP concentration in treated soils ranged from 0.015 mg/L to 0.024 mg/L for PCBs, less than 0.004 mg/L for beryllium, and from less 0.005 mg/L to 0.0029 mg/L for cadmium. These concentrations are all well below ten times the UTS standards. Thus TCLP concentrations for treated and untreated soil were also well below the treatment requirements for Corrective Action Management Unit (CAMU)-eligible waste where the concentrations must be less than 10 times the UTS.

E-4.3. Task 3: Solidification Testing Using Binding Agents

The initial results indicated that the solidification agents tested conferred considerable strength and stability to the soils as shown by the large increase in UCS values that resulted from the treatments. Given the initial results indicated that leaching was not significantly reduced by the reagent options tested in Task 2 (although a significant increase in soil strength was achieved), additional testing was performed where binding agents were added to the soil in addition to the reagents.

In Task 2, the greatest increase in UCS was achieved by the samples treated with 5% Portland cement, and with 2.5% Portland cement and 2.5% cement kiln dust. Therefore,

these reagents were added along with 1% (weight/weight [w/w] soil) of binding agents known to absorb organic compounds. The binding agents tested were organo clay (a blend of anthracite and bentonite clay that has been impregnated with a quaternary amine and contains approximately 16% organic matter), granular activated carbon (GAC), and Petroloc® (a proprietary binding agent).

As before, the tests were prepared by placing soil with the appropriate mass of solidification reagents, binding agent, and water in a mechanical mixer. The soil, water, and reagents were mixed for five 5 minutes and then compacted into a plastic mold. The mold was placed in a high humidity chamber for curing. After two weeks, the test samples were analyzed for TCLP PCB and TCLP metals (Be, Cd, and Cu). Two test samples were also analyzed for UCS to ensure that the binding agents did not compromise the solidification of the soil.

The results of the additional solidification tests are summarized in Table E-3 and on Figure E-2. The UCS testing performed on the samples treated with organo clay identified that it did not significantly impact the UCS obtained with either 5% Portland cement or 2.5 % Portland cement and 2.5% cement kiln dust alone. UCS results were 246 psi for the sample treated with 5% Portland cement and 98 psi for the sample treated with 2.5% Portland cement and 2.5% cement kiln dust compared to 126 psi and 123 psi, respectively, obtained when organo clay was not added.

Leaching of Aroclor 1254 from the solidified samples was decreased somewhat by the use of both organo clay and Petroloc®. Organo clay and Petroloc® reduced PCB leaching by 20% and 29%, respectively. Activated carbon did not reduce leaching of PCBs. As with Task 2, no heat appeared to be generated by the reactions of the reagents during mixing.

The additional testing results indicate that the leaching of Aroclor 1254 and co-located metals can be decreased by approximately 20% by the addition of binding agents such as 1% organo clay. A slightly greater decrease was found when Petroloc® was used, however, it has a significantly higher cost, which would likely not be justified by the minimal decrease in leaching. However, because PCB leaching is very low in the untreated soil sample, PCBs have low solubility, and ground water has not been impacted by PCBs in Building 850 soil and modeling indicates it will not be impacted, the addition of these binding agents to further reduce leachability is not warranted.

E-5. Summary

The following provides a summary of the key findings:

- Treatment of the soil sample with reagents tested should solidify the soil sufficiently to mitigate exposure to onsite workers and ecological receptors.
- Treatment of the soil sample with solidification reagents successfully increased the UCS of the soil.
- 5% Portland cement and 2.5% Portland cement with 2.5% cement kiln dust achieved the highest UCS values for the reagents tested.

- Although the composite soil sample contained Aroclor 1254 at 220 mg/kg, the TCLP test leached only 13 µg/L Aroclor 1254 from the soil, indicating PCB leaching is very low in the untreated soil sample.
- Treatment of the soil sample with solidification agents alone did not significantly decrease the small amount of leaching of PCBs observed in the untreated sample.
- Treatment of the soil sample with solidification reagents and binding agents (organo clay and Petroloc®) produced a 20% to 29% reduction in leaching of PCBs without substantially decreasing the UCS of the soil. Although published data on the strength requirements suitable for preventing burrowing by animals are not available, the resulting strength obtained from the solidification should be sufficient to deter burrowing animals from digging into the consolidated material.
- The strength obtained from the study, if the solidified soil was compacted using standard placement and compaction techniques, would be suitable for the construction of a consolidation area that would be appropriate for carrying loads typically observed in an asphalt paved area.
- Weathering of the compacted soils would not be a significant concern because the soils would be covered and not exposed to the natural elements.

E-6. Conclusions and Recommendations

The UCS testing confirmed that the reagents tested should solidify the soil sufficiently to mitigate exposure to onsite workers and ecological receptors, deter burrowing animals from penetrating the consolidated material, and to support the construction of a asphalt parking area or area for similar uses, i.e. storage or staging. Using either 5% Portland cement or 2.5% Portland cement and 2.5% cement kiln dust results in a high strength that will achieve these goals. Because cement kiln dust is less expensive than Portland cement, solidification with 2.5% Portland cement and 2.5% cement kiln dust is recommended as the most cost effective solidification treatment. For one ton of soil, 55 pounds of Portland cement, and 55 pounds of cement kiln dust would be required.

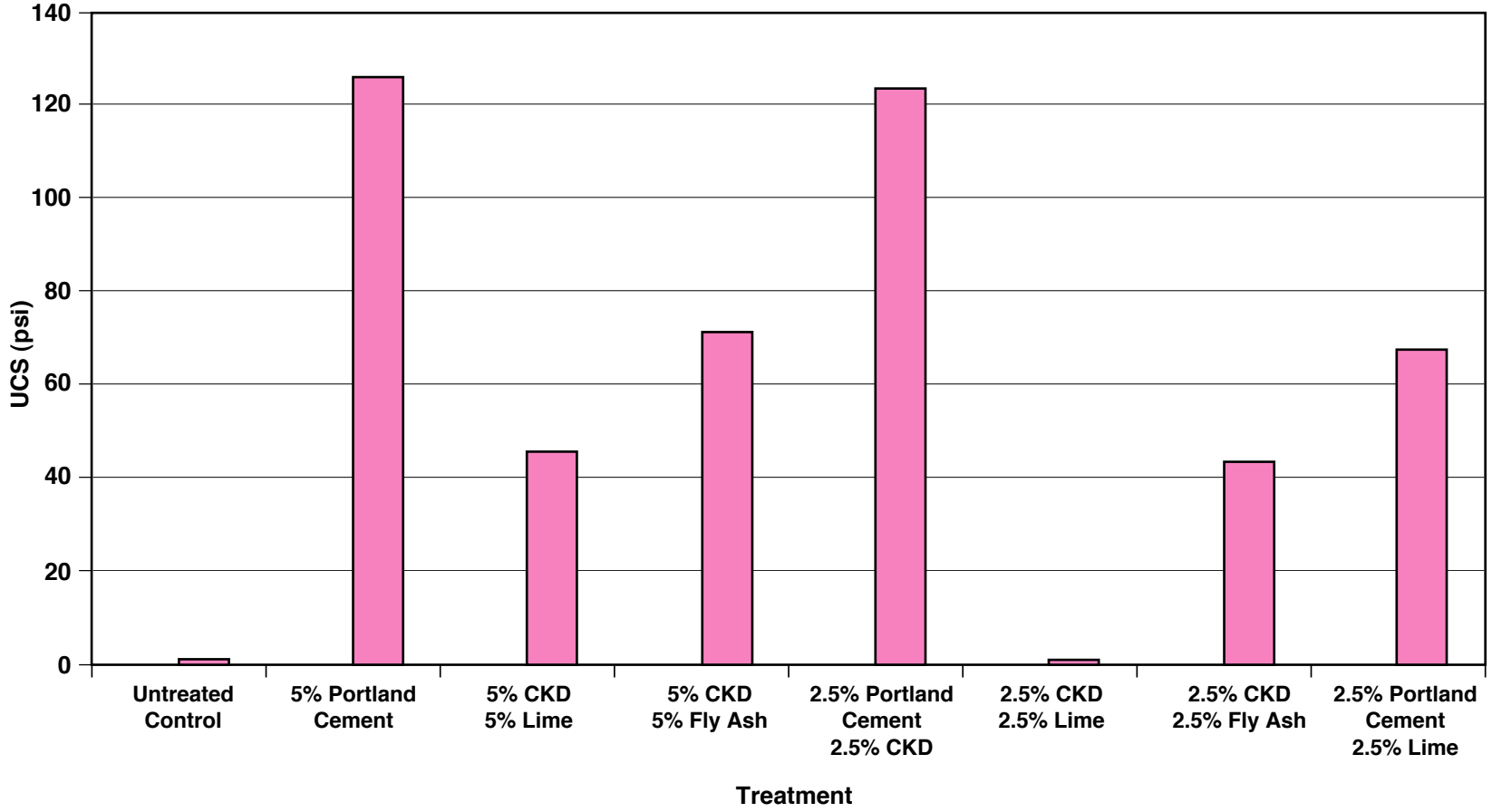
The leaching of Aroclor 1254 and co-located metals in untreated soil from the site was very low. The leaching can be decreased by approximately 20% by the addition of binding agents such as 1% organo clay. A slightly greater decrease was found when Petroloc® was used, however, it has a significantly higher cost, which would likely not be justified by the decrease in leaching. However, a further reduction of leachability is not an objective of the removal action because PCB leaching is very low in the untreated soil sample, PCBs have low solubility, and ground water has not been impacted by PCBs in Building 850 soil and modeling indicates it will not be impacted.

Test results for the untreated control soil from Building 850 indicate that PCB (Aroclor 1254) concentrations in the leachate (0.021 mg/L) were less than ten times the 0.10 mg/L Universal Treatment Standard (UTS) for PCBs and therefore meets the treatment requirement for CAMU-eligible wastes that the concentrations must be less than 10 times the UTS. Test results for

untreated soil also indicate that the TCLP concentrations for beryllium (0.00058 mg/L) and cadmium (0.0017 mg/L) were well below the UTS of 1.22 mg/L and 0.11 mg/L, respectively. The TCLP concentration for copper in the untreated sample was 0.19 mg/L. There is no UTS (TCLP) concentration for copper. TCLP concentration in treated soils ranged from 0.015 mg/L to 0.024 mg/L for PCBs, less than 0.004 mg/L for beryllium, and from less 0.005 mg/L to 0.0029 mg/L for cadmium. These concentrations are also all well below 10 times the UTS standards. Thus TCLP concentrations in treated and untreated soil were also well below the treatment requirements for Corrective Action Management Unit (CAMU)-eligible waste where the concentrations must be less than 10 times the UTS.

Appendix E

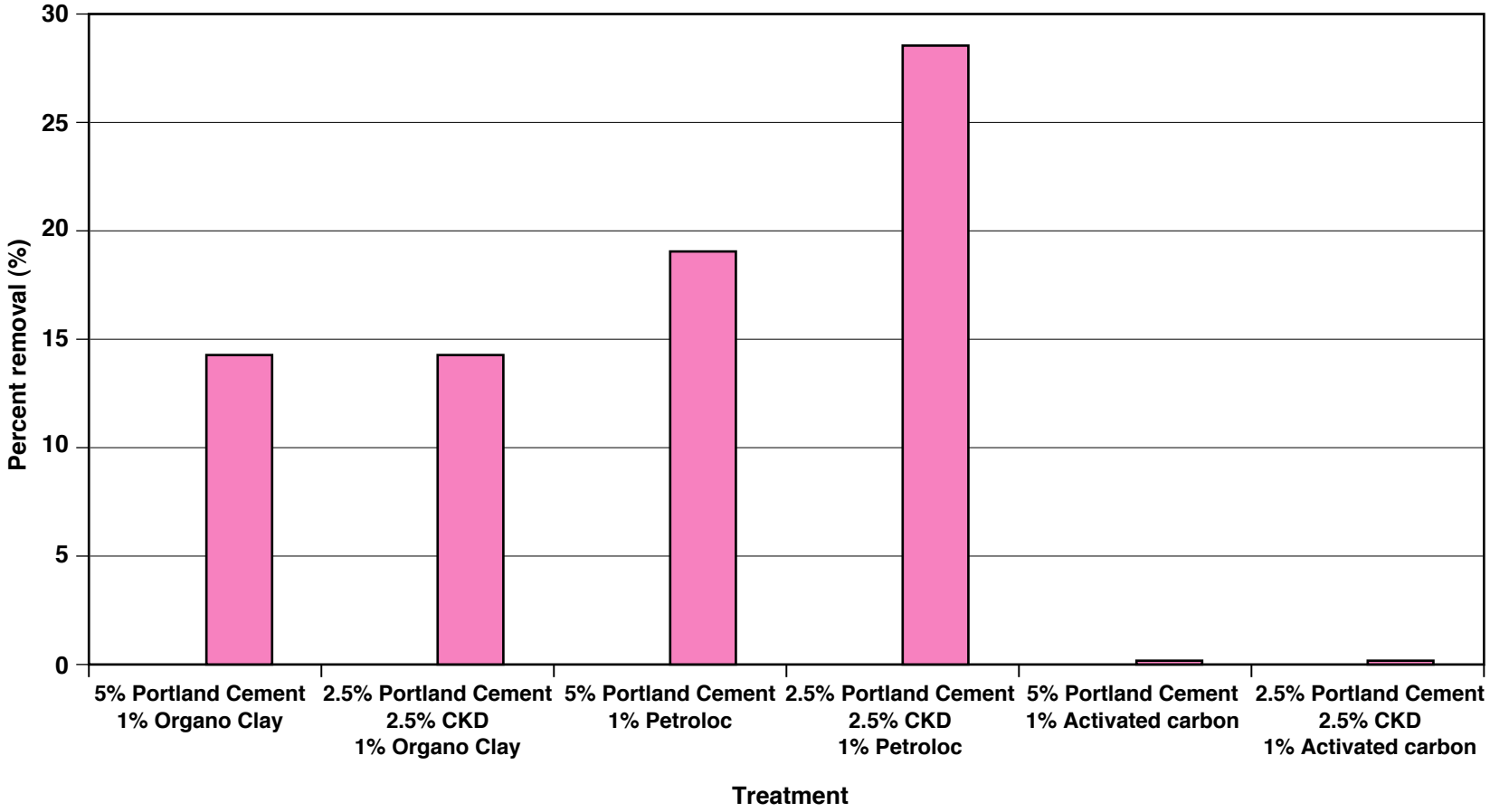
Figures



Note: CKD = cement kiln dust

ERD-S3R-07-0109

Figure E-1. Unconfined compressive strength (OCS) of treated samples.



Note: CKD = cement kiln dust

ERD-S3R-07-0108

Figure E-2. Percent removal of leaching for Aroclor 1254.

Appendix E

Tables

Table E-1. Initial characterization of soil composite.

Parameter	Units	Composite Soil Sample
General		
pH	**S.U.**	**7.7**
Moisture Content	**%**	**3.8**
Total Organic Matter	**%**	**1.12**
Porosity	**%**	**33**
Polychlorinated Biphenyls (Total)		
Aroclor 1060	**mg/kg**	**ND (3.4)**
Aroclor 1221	**mg/kg**	**ND (3.4)**
Aroclor 1232	**mg/kg**	**ND (3.4)**
Aroclor 1242	**mg/kg**	**ND (3.4)**
Aroclor 1248	**mg/kg**	**ND (3.4)**
Aroclor 1254	**mg/kg**	**220**
Aroclor 1260	**mg/kg**	**ND (3.4)**
Metals (Total)		
Beryllium	**mg/kg**	**0.51**
Cadmium	**mg/kg**	**0.62**
Copper	**mg/kg**	**132**
TCLP Polychlorinated Biphenyls		
Aroclor 1060	**µg/L**	**ND (1.0)**
Aroclor 1221	**µg/L**	**ND (1.0)**
Aroclor 1232	**µg/L**	**ND (1.0)**
Aroclor 1242	**µg/L**	**ND (1.0)**
Aroclor 1248	**µg/L**	**ND (1.0)**
Aroclor 1254	**µg/L**	**13**
Aroclor 1260	**µg/L**	**ND (1.0)**
TCLP Metals		
Beryllium	**mg/L**	**0.00059**
Cadmium	**mg/L**	**0.0025**
Copper	**mg/L**	**0.24**

Notes:

% = Percent
µg/L = microgram per liter
mg/L = milligram per liter
ND () = Not detected at the reporting limit specified in parentheses
S.U. = Standard Units
TCLP = Toxicity Characteristic Leaching Procedure

Table E-2. Leaching data for samples treated with solidification reagents.

	Units	5% Portland Cement	5% CKD 5% Lime	5% CKD 5% Fly Ash	2.5% Portland Cement 2.5% CKD	2.5% CKD 2.5% Lime	2.5% CKD 2.5% Fly Ash	2.5% Portland Cement 2.5% Lime	Untreated Control
UCS	psf	18140	6540	10235	17732	too fragile	6221	9685	too fragile
UCS	psi	126	45	71	123	too fragile	43	67	too fragile
TCLP PCB									
Aroclor 1060	µg/L	ND (0.95)	ND (0.98)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1221	µg/L	ND (0.95)	ND (0.98)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1232	µg/L	ND (0.95)	ND (0.98)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1242	µg/L	ND (0.95)	ND (0.98)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1248	µg/L	ND (0.95)	ND (0.98)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1254	µg/L	25	21	24	24	20	20	24	21
Aroclor 1260	µg/L	ND (0.95)	ND (0.98)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
TCLP Metals									
Beryllium	mg/L	0.00031 B	0.0011 B	0.00047 B	0.00052 B	0.0011 B	0.00071 B	0.00075 B	0.00058 B
Cadmium	mg/L	ND (0.10)	0.0032 B	ND (0.10)	0.0034 B	0.0040 B	0.0025 B	0.0064 B	0.0017 B
Copper	mg/L	0.18	0.22	0.13	0.18	0.24	0.15	0.24	0.19

Notes:

- **% =** Percent
- **µg/L =** microgram per liter
- **B =** Estimated result. Result is less than reporting limit
- **CKD =** Cement Kiln Dust
- **mg/L =** milligram per liter
- **ND () =** Not detected at the reporting limit specified in parentheses
- **PCBs =** Polychlorinated biphenyls
- **psf =** Pounds per square foot
- **psi =** Pounds per square inch
- **S.U. =** Standard Units
- **TCLP =** Toxicity Characteristic Leaching Procedure
- **UCS =** Unconfined Compressive Strength

Table E-3. Leaching data for samples treated with solidification reagents and binding agents.

	Units	5% Portland Cement 1% Organo Clay	2.5% Portland Cement 2.5% CKD 1% Organo Clay	5% Portland Cement 1% Petroloc	2.5% Portland Cement 2.5% CKD 1% Petroloc	5% Portland Cement 1% Activated Carbon	2.5% Portland Cement 2.5% CKD 1% Activated Carbon	Untreated Control
UCS	psf	35417	14167	n/a	n/a	n/a	n/a	too fragile
UCS	psi	246	98	n/a	n/a	n/a	n/a	too fragile
TCLP PCB								
Aroclor 1060	µg/L	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1221	µg/L	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1232	µg/L	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1242	µg/L	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1248	µg/L	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
Aroclor 1254	µg/L	18	18	17	15	22	24	21
Aroclor 1260	µg/L	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)	ND (0.95)
TCLP Metals								
Beryllium	mg/L	ND (0.0040)	ND (0.0040)	ND (0.0040)	ND (0.0040)	ND (0.0040)	ND (0.0040)	0.00058 B
Cadmium	mg/L	ND (0.0050)	0.0029 B	ND (0.0050)	0.0025 B	ND (0.0050)	0.0014 B	0.0017 B
Copper	mg/L	0.23	0.17	0.19	0.16	0.13	0.086	0.19

Notes:

- **% =** Percent
- **µg/L =** microgram per liter
- **B =** Estimated result. Result is less than reporting limit
- **CKD =** Cement Kiln Dust
- **mg/L =** milligram per liter
- **n/a =** Not analyzed
- **ND () =** Not detected at the reporting limit specified in parentheses
- **PCBs =** Polychlorinated biphenyls
- **psf =** Pounds per square foot
- **psi =** Pounds per square inch
- **S.U. =** Standard Units
- **TCLP =** Toxicity Characteristic Leaching Procedure
- **UCS =** Unconfined Compressive Strength

LAWRENCE LIVERMORE
NATIONAL LABORATORY
Lawrence Livermore National Security, LLC • Livermore, California • 94550